A TEXT BOOK OF
CROP SYSTEMATICS

K. L. MUKHERJEE
AND
BIBHA MUKHERJEE

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CROP SYSTEMATICS

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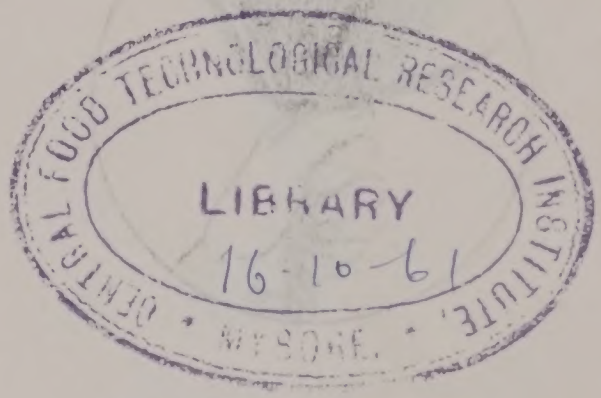

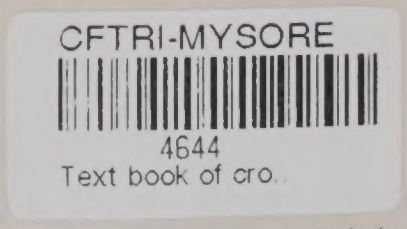

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DEDICATED

TO

OUR STUDENTS

PREFACE

This book is being written for students who are preparing for their degree course in agriculture. The need for writing a Systematic Botany dealing with Indian agricultural crops (Crop Systematics) has been a long felt demand for students for agriculture in our country. This being a compulsory subject in every college of agriculture, universities have been forced to prescribe books written mainly for botany students or such books by foreign authors in which Indian conditions are very scantily dealt.

The method of appproach for the study of cultivated plants by a botanist is somewhat different from that of an agricultural botanist. An agriculural botanist, apart from the study of the crops as an identified species of the plant kingdom, tries to account for its origin and cultivation, economic importance and position in world trade, soil and climatic requirements and also its pests and diseases; much of which comes under the domain of agrogeography. This book, therefore, is an attempt to bring into blending the ideas of an agricultural botanist and that of an agrogeographer, based on the experience we have gained by our teaching in the last few years.

The book is divided into three parts. Part One gives in short the devlopment and theoretical considerations of taxonomy, the segregation of crop systematics from the broader field of systematic botany and application of the knowledge of crop systematics in agriculture. Part Two gives the morphological description of Minocotyledonous crops and Part Three deals with Dicotyledonous crops. This covers 16 orders, 20 families, 47 genera and 51 species, all of which are concerned with important Indian crops.

Several marked departures from the existing works will be obviously visible. Every crop is preceded with a short account of its agrogeography and position in Indian agriculture. Anatomical peculiarities of several crops have been described which are commonly given in practical classes. The technical terms used in the text may not be intelligible for the beginners who are more familiar with Hindi terms, hence a glossary has been given at the end explaining all the terms used. Common

Hindi synonyms of the crops dealt here have been provided wherever possible. References have been given as 'selected' and 'general'; the former at the end of individual crops or topics, and the latter at the end of the text. The majority of these references are relating to Indian works on the subject. The classification followed in the text is essentially that of Engler modified by Rendle on the ground that it is more recent and widely accepted. The orders and genera are described in short, bringing to light their salient characters which separate them from their allied groups, while the families and species are described at length. In the description of families, floral characters have been given priority while the common traditional method has been followed in the case of species. The crops are well illustrated. Floral diagrams and floral formulae are provided along with the morphological descriptions of crops. Likely that there be a repetition of facts while dealing with the descriptions of the characters of orders, families, genera and species in sequence, but that is more on purpose to avoid confusion in the minds of beginners.

It must be admited at the very outset that there are a number of limitations in this book. Some of the important crops including a few narcotics, millets, fibre crops, fruits etc. (majority of which are not prescribed by Indian Universities) could not be dealt with. But it is hoped that the second edition will bring out rest of the details.

This book is only a compilation of the information that is scattered about in various journals and books and our aim, therefore, is to present a connected and comprehensible view on the subject.

We wish to express our gratitude to our professors Dr. K. N. Lal and Mr. B. Ganguli for their cooperation and enthusiastic support.

We are also grateful to Dr. R. S. Choudhri (Reader in Crop Botany, Varanasi Hindu University) and Dr. R. L. Singh (Head of the Dept. Geography, B.H.U.) and our thanks are to other teachers as well as our colleagues and students for their kind help. We are specially indebted to Dr. R. Misra (Head of the Dept. Botany, B.H.U.) and Prof. A. K. Ghosh (Natural Oils and Gases, Dehradun) for going through the entire manuscript, and obliging us by their helpful criticisms and invaluable suggestions.

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Most of the illustrations are redrawn from various books referred to the end, and have been done by Mr. S. Prasad.

DEORIA — BIBHA MUKHERJEE

1st. January, 1958 — K. L. MUKHERJEE

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PART I

PRINCIPLES OF CROP SYSTEMATICS

CHAPTER I

INTRODUCTORY

General Consideration :

'Biology' is that branch of science which deals with living objects while 'Botany' is specifically concerned with the study of plants, both present and past. This embraces within its scope their various forms, external and internal structure, mode of living, reproduction, hereditary processes, line of descent (phylogeny), relationship with each other and with the environment and ultimately their varied uses and methods to make them most useful to man.

The absolute dependence of man (and other animals) upon plants and the myriad purposes that they serve for mankind need no emphasis. The green plants offer the greatest means of utilizing the solar energy and thereafter converting it into energy-providing foods and they are as well the sole purifiers of air. Higher plants provide the fundamental needs of man—food, fuel, clothing and building materials, and also materials for beverage, drugs, narcotics and host of other things feeding various industries. Lower plants are the saviours of society through their decaying action on dead bodies of plants and animals. Apart from this they have ever so many biological, economical, industrial and medicinal uses. The soil microflora contributes considerably towards soil fertility. They are also responsible for many diseases and deformities in plants and animals.

Considering the indispensability of plants in human life, a detailed study of them with all their bearings becomes an integral part of modern scientific knowledge.

Agricultural Botany and its Scope :

Botany is often divided into 'pure botany' and 'applied botany'. Pure botany deals with the fundamental study of plants as they form a part of nature while applied botany focusses its attention only on its practical application and tries to 'train' plants to serve mankind well. In fact, the mere assemblage of the theoretical knowledge of pure botany becomes ineffective unless it is bound by its applicability, but at the

same time it forms the foundation stone for the study of applied botany at a later stage.

'Agricultural Botany' is the most important branch of applied botany and deals with the study of cultivated plants. The objects of studying agricultural botany are two-fold, firstly and mainly to meet human wants and secondly to make agriculture a more economic and profitable business. The subject matter of agricultural botany is similar to other branches of pure botany but the approach in such studies is from the applied point of view.

Systematic botany or *plant taxonomy* includes identification, nomenclature and classification of plants and when applied to agricultural crops it is commonly termed as **"Crop Systematics".** This is based fundamentally on the study of morphology with the support of all interrelated sciences and assists in "seeing through" a plant more closely and understanding better their life processes. It also explains the distinctions and affinities of various plant groups. These affinities help in knowing their habits, needs, possibilities of grafting and breeding etc. and their distinctions assist in regularizing the crop rotation while the knowledge of anthesis and pollination is utilized in plant breeding. The other aspect of taxonomy, viz. the knowledge of the existing natural flora of the area, helps not only to understand the possible natural resources available for use, but also pictures the land potentials and soil fertility status.

Plant physiology is an important branch of botany and constitutes the study of the internal functions, life processes and basic requirements of plants. This when studied from the viewpoint of **"Crop Physiology"**, is helpful in judging the optimum environments, especially aeration, irrigation and nutrition necessary for the best output of the crop. The knowledge of physiology is also utilized in controlling the natural processes such as shortening of growth period, attainment of rapid growth in plants, control of germination and breaking of dormancy, initiation of rooting, regulation of flowering and fruiting, increase of photosynthetic efficiency and absorption of water and nutrients and lastly suppression of undesirable plants by physiological means through the use of herbicides and these were until now considered to be independent and uncontrolled.

Anatomy forms the foundation for the study of physiology

since the functions of an organ cannot be properly understood without a knowledge of its structure. It has also considerably helped in understanding the process of adaptation by plants in response to their environment. Anatomical studies are also necessary for understanding the mode of infection and life history of pathogenic organisms and this facilitates the diagnosis, prevention and cure of various plant diseases. *Cytology* is that branch of anatomy which deals with cell structure. During recent years spectacular progress has been made in the field of genetics, and cytological studies have successfully unravelled the conceptions of *"gene theory"* and *"the theory of inheritance"*. According to Hector, these discoveries have enabled the plant breeders to rebuild the "constitution" of our agricultural plants and ultimately to synthesize the existing species into new reaction systems. Through this approach, important advances in agricultural productivity have been attained and many of the undesirable qualities of crops have been successfully ruled out.

Until recently the role of *ecology* in agriculture was only incidental. It is now, however, being increasingly realized that for the maximum yield in any area, the knowledge of crop ecology is essential and in addition, the significance of edaphic and climatic factors (most important being rainfall, temperature and photoperiod) affecting the geographical distribution of plants must be understood, so as to pave the way to the development of "adjusted agriculture".

It will be too lengthy a topic to attempt a discussion on all the varied applications of botanical knowledge in agriculture, but it is certain that, in order to achieve success, a student in the field of agriculture needs a clear grasp of fundamental botany.

CHAPTER II

SYSTEMATIC BOTANY AND CROP SYSTEMATICS

A. SYSTEMATIC BOTANY

Introduction :

On the face of the earth there exists today over a quarter of a million different kinds of plants and many more are yet to be discovered. A great many kinds which flourished in the past are now extinct. The indispensability of plants for the existence of man and myriad purposes that they serve for mankind make it necessary to arrange them in some orderly manner.

The primitive people in order to serve their purpose were contented with associating certain names to those plants only which were especially useful, harmful or interesting. Due to lack of communications there existed a great dearth of knowledge regarding the innumerable existing species and hence the establishment of their phylogenetic relationships were rarely thought of. With the growth of civilization and advancement of scientific thinking, the consideration of all plants irrespective of their particular role was eventually realised.

The object of systematic botany or plant taxonomy is to identify, name and classify plants by their affinities and structural resemblances in a manner by which their phylogenetic relationship can be established and their line of evolution be traced.

Systems of Plant Classification :

Such plant classifications as agronomical, economical, horticultural, medicinal and such like are partial as they are made to meet some particular purpose in view and hence remain incomplete and fragmentary. Plants that do not fit into these classifications are usually ignored. As mentioned earlier, a true botanical classification takes into account the whole plant kingdom as it exists in nature and is based on the hypothesis that genetical relationships exist between plants and that the present day plants are through successive generations, the offsprings of ancestral plants that may or may not now be extant.

Historical Resume :

The fascinating history of plant classification begins with the pioneer work of the Greek philosopher Theophrastus (370–285 B.C.) who is acclaimed the Father of Botany. Ever since his time, many attempts have been made to attain an ideal system of plant classification but it was only since 1600 A.D. that the advance has become more rapid and Carolus Linnaeus (1707–1778), is regarded as the most important representative of this period and also the most prodigious systematist of all times. The systems proposed by Lamarck (1778), de Jussieu (1774), de Candolle (1806–1893), Bentham and Hooker (1862–1883), Eichler (1875), Engler (1892), Wettstein (1901), Bessey (1915), Rendle (1925), Mez (1926), Tippo (1942) and Hutchinson (1948) are more notable and the work of each one of them represents a distinct advance over the predecessors.

Types of Plant Classification :

All the various systems of plant classification so far proposed are recognisable as being or approaching one of the three types artificial, natural and phylogenetic. The artificial system of classification which is getting out of date nowadays, classifies organisms for convenience, primarily as an aid to identification based upon one or few prominent morphological characters, e.g., habit, sexual organs etc., ignoring their natural or phyletic relationship. The natural system of classification, on the other hand, far from being a simple key to plant identification, reflects the situation as it exists in nature utilizing all informations available at the time. All the earlier classifications, including the sexual system of Linnaeus were very largely artificial and supported by the followers of the dogma of *"Special Creation"* (living organisms are specially and separately created by the Divine power according to a perfect plan) and the *theory of "Constancy of Species"* (once created, no kind of organism could ever give rise to any other kind). Darwin's *'theory of evolution'* brought about the refutation of the former notions and thereafter came the concept that there exists some relationship in the sense of common descent, between different species. Thus more recently, attempts are being made to classify plants according to their evolutionary sequence which should reflect their genetic relationships and enable one to

determine at a glance the ancestors or derivatives (when present) of any individual. Such a classification is called *"phylogenetic system"*.

As the existing knowledge of the origins and relationships pertaining to all texa is incomplete, it is not possible for us to classify plants being strictly phylogenetic. Accordingly, our present day classifications in reality are mixed up and are based on the combination of partly natural and partly phylogenetic systems. The principal goal of the plant systematist is, however, to work out a classification which will establish as closely as possible the evolutionary history of a taxon and also form a handy key to the identification of new species.

The modern systematists are using one of four basic systems of plant classification, or their modifications, brought forward by Bentham and Hooker, Engler, Bessey and Hutchinson. Inspite of these systems which appear to be superflous and overlapping and the prevalent idea that these could be synthesized to a single system that might be universally accepted, a closer examination indicates that there is reason for such a variety in the different systems. The classification system followed in this text is not strictly phylogenetic as described by Rendle (1925) which is a modification over that of Engler.

Principles of Plant Classification :

No two individuals can be identical although they may resemble in certain of their characters while differing in others. This difference is a natural phenomenon and is caused either by the influence of environment, recombination of characters or by mutation and once brought about, the variants are faithfully and constantly propagated. This causes the evolution of new species often with increased structural complexity and genetic organization over their ancestors. If one could trace the lines of the descent in various plant groups he would find that all the extant individuals whose phylogenetic relationship is sometimes subjected to much disputable conjectures due to their lost link and little resemblances, were originally descended from one or a few closely related simple organisms. This leads to the conclusion that perhaps all plant individuals are related or at least that within each of a few great groups of plants, all individuals have their lineage from the same remote ancestors.

Basis of Classification :

The present day classification of plants although primarily based on the morphological distinction and affinity is also largely influenced by the findings of anatomical, cytological, genetical and other allied botanical sciences. Amongst the various morphological criteria that are discernible to the naked eye or with the aid of no more than a good hand lens, the dependability of the character rests on their degree of constancy. The more constant the character in relation to environmental changes, the greater is the reliability that can be placed upon it, and the reproductive characters of a plant, on account of their greater stability, are taken to be the basis of plant classification.

Units of Classification and Plant Nomenclature :

This can be broadly grouped under three categories: (a) Major, (b) Minor and (c) Infraspecific.

The *major categories* include the main *"divisions"* of the plant kingdom which are further divided into *"subdivisions"*. A division (or subdivision) constitutes of the closely related *"classes"* or *"subclasses"*. The classes (or subclasses) are the representatives of distinctly related *"orders"*. An order comprises of one or more *"families"* which conventionally end with *'–aceae'* or *'–ae'*. The family usually represents a more natural unit than any of the higher categories. When a family is large and comprises many components, it is often divided into phyletic units called *"subfamilies"* (ending with *'–oideae'*) and a subfamily into *"tribes"* (ending with *'–eae'*) and *"subtribes"* (ending with *'–inae'*).

The units of *minor categories* are those which become a part of the plant nomenclature. According to International Rules of Botanical Nomenclature (Sixth International Botanical Congress at Amsterdam, 1935 and further revised by the American Society of Plant Taxonomists in 1946-47), the modern taxonomists are following the *"binomial nomenclature method"* for the naming of plants. This is a combination of the *'generic'* and *'specific'* names along with the name of the person who first identified or named the plant. For example, the common cultivated barley is botanically known as *Hordeum vulgare* Linn., meaning thereby that it belongs to the genus 'Hordeum' (first of the two words comprising a binomial, always capi-

talized and always in a singular number) with the specific name 'vulgare' (implying common) and was originally named by Linnaeus. With the universal approval of this system of giving scientific names instead of the names in common use or of specific language, much misunderstanding has been removed.

The *"genus"* is subordinate to the family and each family comprises of one or more genera. For reasons of phyletic clarity and convenience in classification the category of genus is sometimes subdivided into sub-genera, sections, subsections, and series, but these are not included in the nomenclature. The *"species"*, on the other hand, are considered the basic unit of all taxonomic work and defined as *a collection of individuals which are very much alike and assumed to be more closely related or more recently descended from the same ancestor.*

Variations below the rank of species like sub-species, varieties, forms, races, strains, clones and others, depending on such minor characters as the yield and quality of produce, resistance to disease, plant vigour, flower colour etc., are considered under the *infraspecific categories.* Such variations may little justify the application of a new specific name, yet are of sufficient importance to be pointed out. This is particularly true of cultivated plants. In this instance a new unit 'variety', is added to the binomial, and the name becomes in fact a trinomial. Thus, *Mangifera indica* Langra designates 'Langra' variety of mango. This is in common use amongst crop growers but due to the evolution of numerous varieties, the identification of correct variety has become a difficult task. For an ordinary farmer this has created much confusion which can only be removed by the frequent publications of varietal classificatory guides by the research departments and keep the farmers well informed of the characters and qualities of the improved varieties adapted to local conditions.

Apart from the infraspecific units, many more technical units of differentiation have originated during recent years, e.g. pure lines, ecotypes, phenotypes, genotypes, etc., which could not yet be assimilated into any classificatory scheme and they remain as loose pages of a book that need proper arrangement.

Before concluding, it needs to be stated that it is only the individual organisms which actually exist, while divisions, subdivisions, orders, families, genera, species etc., are nothing but

mental conceptions of various groups of individuals which can be closely or distantly related.

B. CROP SYSTEMATICS

Introduction :

'Crop systematics' forms an important branch of applied taxonomy but as it is a more recent development, its scope and limitations have not yet been fully defined. A study of the cultivated species with their identification, classification, naming and preparation of world monographs is of paramount importance. Until now this fertile field was quite neglected and the cultivated plants were simply considered to be one of the taxon of the existing natural flora. With the advance made in agricultural science the cultivated flora presents a different picture than that of the natural ones and therefore, a separate consideration of the taxonomic study of crop plants becomes necessary. The cultivated plants vary from their original wild ancestors due to certain outstanding causes such as their having no geographical boundaries and being exotic to any part of the globe wherever they can be economically grown; they are artificially cultured and taken care of in order to meet human needs and wishes; they have greater resistance to unfavourable conditions; new varieties are evolved artificially with a view to synthesize the existing species into a new improved reaction system.

One of the greatest problems facing the crop systematists today is the possession of a detail world monograph of all the cultivated species. The approach to this line by Vavilov (1926) and Bailey (1949) is praiseworthy but this needs to be implemented with larger and better world monographs of cultivated species and revisions of their families and genera by trained taxonomists keeping primarily in view the needs of the agricultural botanists.

Taxonomic Position of Agricultural Crops :

Cryptogams and *Phanerogams* are two main divisions of the plant kingdom. Cryptogams do not produce evident flowers or seeds and their method of reproduction is not easily discernible. Phanerogams, on the other hand, are characterised by their *"flowering habit"* and formation of seeds. These

flowers contain distinct male and female organs which respectively contain dissimilar male and female sexual cells known as *'gametes'*. During sexual reproduction, these gametes fuse together and give rise to the seed embryo *sporophyte.*

Cryptogams include algae, fungi, bacteria, viruses, liverworts, mosses and ferns. A study of some of these in relation to agricultural science is undoubtedly essential. Many of the micro-organisms (fungi, bacteria and viruses) are the causal agents for various crop diseases while others have many important beneficial roles to play. Collectively, algae, fungi and bacteria make up most of the soil flora and these are considered as important for soil fertility. Fungi and bacteria are the cleansing agents which perform their function through the decaying process on plant and animal bodies, nowadays they are also utilised for various industrial processes and the production of antibiotics and at times even as food for human consumption. Ferns too have a great biological and economic importance apart from their use as garden ornamental. The scope of this book does not allow further consideration of these lower plants.

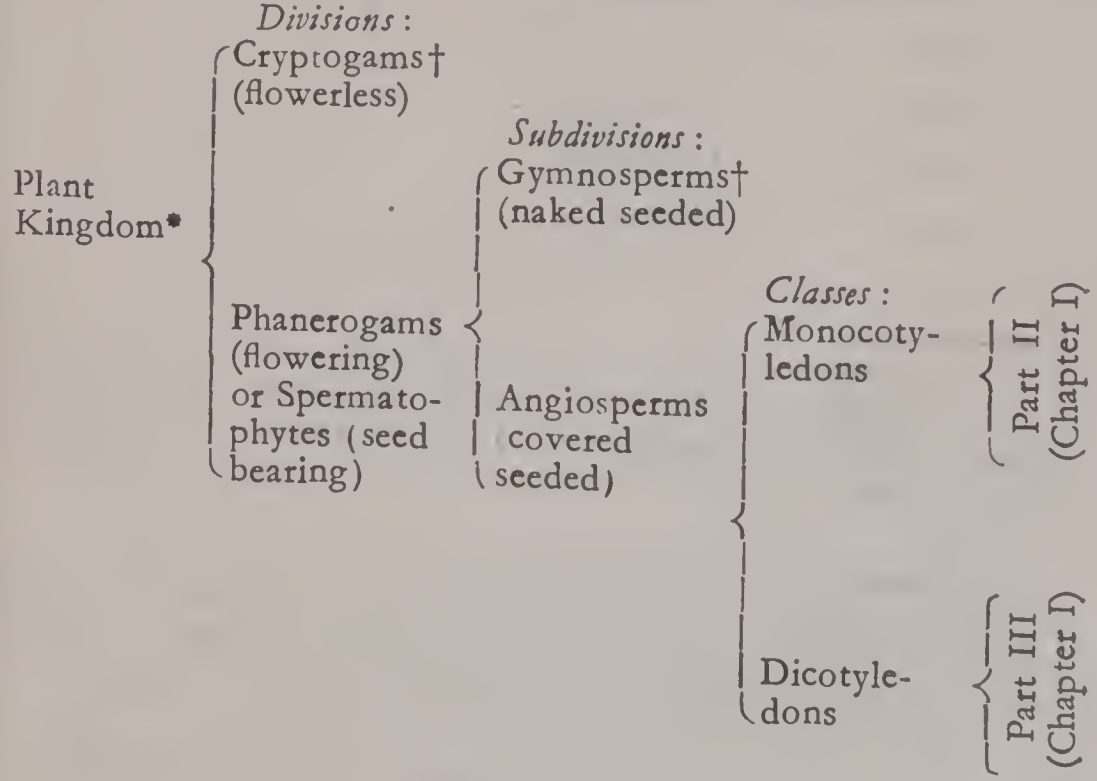
The *'flowering plants'* or Phanerogams fall into two well marked subdivisions—*Gymnosperms* and *Angiosperms.* The Gymnosperms are differentiated from Angiosperms by the possession of their exposed ovules (hence the name gymnosperm, meaning "naked seed") or primitive and very simple unisexual flowers, a simpler process of fertilization, with endosperm formed before fertilization. Thus in the process of evolution, Gymnosperms are closely related to the higher cryptogams (liverworts, mosses and ferns) on the one hand, and the Angiosperms on the other, and thus they form an intermediate group between the two. Cycads, yews and pines are important families of Gymnosperms which yield many valuable economic products as timbers, pulp woods, pitch, turpentine, resin, flavouring oil, Canada balsam, various medicines etc., majority of which are forest products. A number of them are cultivated for obtaining sago or as domestic garden ornamentals or for landscape. In Indian agriculture, Gymnosperms do not play any important role and hence have not been considered in the text.

Angiosperms, thus constitute the principal subject matter in our study of 'Crop Systematics' and can be distinguished by

some of their characteristic features. Sex organs are very often surrounded by distinct floral envelopes (perianth); ovules are enclosed in an ovary formed from one or more sporophylls or carpels (hence the name angiosperm, meaning "enclosed seed") and endosperm is formed after fertilization. During the process of pollination in Angiosperms, pollen grains are carried by various agencies to a definite receptive organ (stigma) where they germinate, send the pollen tubes through the style and complete the process of 'double fertilization' inside the ovule. Soon after the pollination and fertilization of the ovules maturation of carpellary tissues occurs with the ovary developing into the fruit and the ovules into seeds. The embryo of Monocotyledons consists of an axis bearing a single terminal cotyledon ("seed leaves") whereas in case of Dicotyledons it bears a pair of lateral cotyledons with a terminal plumule and ending below in a radicle. Other features of importance in the separation of these two groups—Monocotyledons and Dicotyledons—are explained later in the text.

Classification Followed in the Text :

An outline of the system followed in the text for the classification of the important Indian crops is given in the following schedule upto classes and their further divisions have been dealt in Part II (Chapter I) and Part III (Chapter I).



This classification system, originally proposed by Engler in 1897 (modified by Rendle, 1925), is a definite progress over the earlier systems and is now widely accepted. The main principle underlying Engler's system of plant classification is that, the groups of families of Angiosperms are arranged in ascending series according to the increased complexity of the flower as indicated by the character of the accessory whorls. In the earliest types there is no perianth; then only one whorl and in still higher types two whorls of perianth are visible. In case, where two whorls of perianth are present, the whorls may be bract-like or clearly demarcated as calyx and corolla with distinction in colour and form. This is divided into various subclasses where the progress is shown by the condition of the petals of the corolla, sympetalae represents a still more advanced stage than polypetalae. Within the subclass the advance from a lower to a higher stage is indicated through hypogyny, perigyny and epigyny and from an indefinite number of stamens and carpels to a definite number.

The arrangement can thus be shown by taking the example of wheat and showing its systematic position in this system of plant classification :—

Division	:	Phanerogams (Spermatophytes).
Subdivision	:	Angioperms.
Class	:	Monocotyledons.
Order	:	Glumiflorae.
Family	:	Gramineae.
Genus	:	Triticum.
Species	:	*T. vulgare* Vill. (Villars).

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* According to the recent count, the plant kingdom consists of approximately: 200,000 Phanerogams; 118,920 Cryptogams; 199,300 Angiosperms; 700 Gymnosperms; 172,700 Dicotyledons; 26,600 Monocotyledons and in total 340,000 species.

Differences in the estimates of the number of species belonging to different groups occur because of the divergent opinions regarding the authenticity of the named species. Some botanists recognize a greater number of plant groups as true species than others do.

† Do not come within the scope of Crop Systematics.

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PART II

MONOCOTYLEDONOUS CROPS

CHAPTER I

INTRODUCTORY

Characters of Monocotyledons :

The characteristic feature of a Monocotyledon is to bear a single cotyledon where the embryo is more or less surrounded by a copious endosperm (rarely nonendospermic); the plumule is usually lateral with the cotyledon terminal.

The plants are commonly herbaceous, although shrubs and trees are not rare, branching of stem is practically absent and the axillary buds rarely attain full development with the exceptions of the buds developing into tillers. Leaves in most cases are exstipulate and parallel veined with simple cross union and often possess a sheathing base.

The growth of the primary root is in most cases very limited and later it is replaced by a system of secondary adventitious roots developed from the stem. Flowers are frequently in trimerous whorls, $K_3\ C_3\ A_{3+3}\ G_3$, with a tendency in the reduction of carpels and disappearance of the distinction between the calyx and the corolla. Germination of seeds is more or less universally hypogeal.

Anatomical Features :

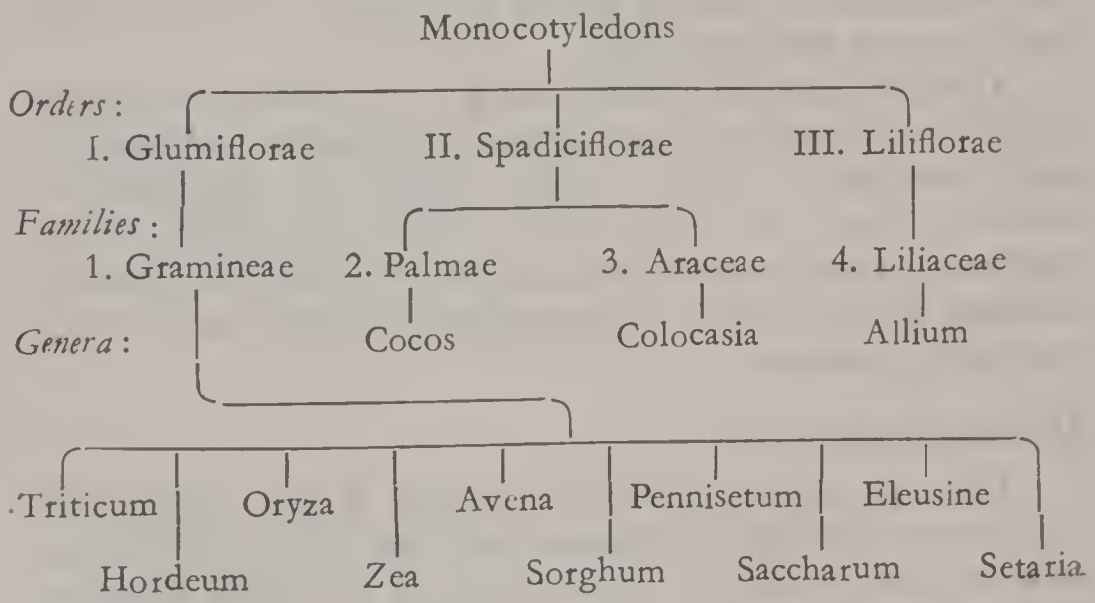
The outstanding anatomical feature of the Angiosperms common to both Monocotyledons and Dicotyledons is the presense of xylem vessels (a vertical series of cells with their end walls resorbed, resulting in the formation of continuous open channels for the passage of water and possibly nutrients).

In the stems of the Monocotyledons, the vascular bundles in general are more numerous in number as compared to dicotyledons and have a 'scattered' arrangement in the ground tissue. The bundles are of the closed type, i.e., there is little or no persistent cambium and therefore, in general, all the tissues of the Monocotyledons are primary tissues. The individual bundles of the Monocotyledons are of two types, amphivasal bundles (a cylinder of xylem surrounding a central core of phloem), and collateral bundles (xylem and phloem lying on

the same radius). But for a few exceptions where a very weak cambium develops in the stem with the production of a small amount of secondary tissue, the lack of a cambium cylinder is related to the absence of secondary growth in the Monocotyledons.

Roots also possess numerous xylem bundles (seldom limited by 5–8) and root cambium is altogether absent, hence secondary growth in root does not occur.

Monocotyledons can be grouped into several well defined orders, each developing on its own lines, but at the present we do not know the exact relationships between these orders. Rendle (1925) has classified the class Monocotyledons into 9 orders and 33 families. Considering the important Indian crops belonging to this class, their systematic position in plant taxonomy can thus be shown:



CHAPTER II

ORDER: GLUMIFLORAE

The order Glumiflorae comprises of two well known families Gramineae and Cyperaceae, of which the former is agriculturally more important.

This order includes annual and perennial herbs, commonly the grasses and sedges, shrubs and tree-like plants. The stem is herbaceous. well marked with nodes and internodes, erect and usually with suckers in Gramineae and rhizomes in Cyperaceae for perennial succession. Leaves are simple, alternate, linear, parallel veined, divided into lamina or blade and sheath, ligulate, auriculate, exstipulate, sessile and cauline. Flowers (or florets) are small, arranged in spikelets, forming a large compound, indefinite inflorescence, enclosed in two outer empty glumes, naked or with a perianth represented by minute scales or bristles called lodicules and bracteate with small scale like bracts—lemma and palea. Stamens usually of one whorl of three, sometimes six or rarely more. Gynoecium 2-3 carpellate, ovary superior, enclosing a single ovule, styles 1—3, stigma usually feathery and laterally exserted. Cross-pollination by anemophily or self-pollinated. Fruit usually a caryopsis or achene. Seeds albuminous containing a well developed embryo.

Family: GRAMINEAE (Grass family)

The Gramineae is most numerous in individuals and a widely distributed family of vascular plants, comprising of about 450—525 genera and 4,500 species. In the natural competition for dominance, the grasses have shown a greater adaptibility which has enabled them to thrive under the most varied conditions—in marshy lands and in thirstly deserts, on sea level and lofty mountains, in sand and clay and in all latitudes from the equator to the arctic except in the most densely shaded forests. In the opinion of present day taxonomists specially dealing with grasses (agrostologists), the great diversities in forms now found in grasses are of more recent origin and the monocarpellary ovary has evolved from ancestral 3-carpelled stocks that had parietal placentation.

The members of Gramineae can be easily recognised by their typical adventitious fibrous root system; majority being herbaceous, erect and with tufted habit. simple, sheathing leaves, very often ligulate and auriculate and with parallel venation; compound spike inflorescence; presence of glumes and bracts (lemma and palea) absence of perianth or represented by two lodicules; stamens trimerous with versatile anthers; monocarpellary with single basal ovule and the fruit, a caryopsis.

Familiar Examples: Wheat or GEHUN (*Triticum vulgare*); barley or JAO (*Hordeum vulgare*); maize or MAKKAI (*Zea mays*); paddy or DHAN (*Oryza sativa*); oats or JAVI (*Avena sativa*); great millet or sorghum grain or JAWAR (*Sorghum vulgare* or *Andropogon sorghum*); pearl millet or BAJRA (*Pennisetum typhoideum*); Italian millet or KANGANI (*Setaria italica*); RAGI (*Eleusine coracana*); sugarcane or GANNA (*Saccharum officinarum*) bamboo or BANS (*Bambusa arundinacea*); CHEENA (*Panicum miliaceum*); DUB (*Cynodon dactylon*).

Floral Characters

Inflorescence: The inflorescence is rather complicated, usually a spike or panicle of spikelets (spikate, paniculate or racemose). So the spikelet is the basic inflorescence unit and may be pedicelled or sessile. Each spikelet has a central axis called rachilla which may be continuous or jointed, subtended by an exposed basal stalk, the pedicel (morphologically a peduncle), a number of alternate bracts are situated at the base and a few to several sessile flowers or florets arranged on the rachilla are enveloped by these bracts. The bracts are known as glumes. Generally in each spikelet, the lowermost two glumes (Glumes I and II) are empty and do not have flowers in their axils. The upper one which is often fertile, has flower in its axil and is called fertile glume or '*lemma*' or Glume III, which may resemble the empty glumes and often greenish, keeled or rounded, nerved, awned or awnless, fertile, enveloping a perfect or pistillate flower or sterile (the flower staminate or none). Within and opposite to the flowering glume there is a bracteole known as '*palea*' or Glume IV which is somewhat smaller and 2-nerved or 2-keeled. Some consider the lemma and palea as lower or outer bract and upper or inner bract respectively, while others call them Glume III and Glume IV. The flower is well pro-

tected in between these glumes and bracts. The shape, texture and venation of the glumes and bracts provide good taxonomic characters.

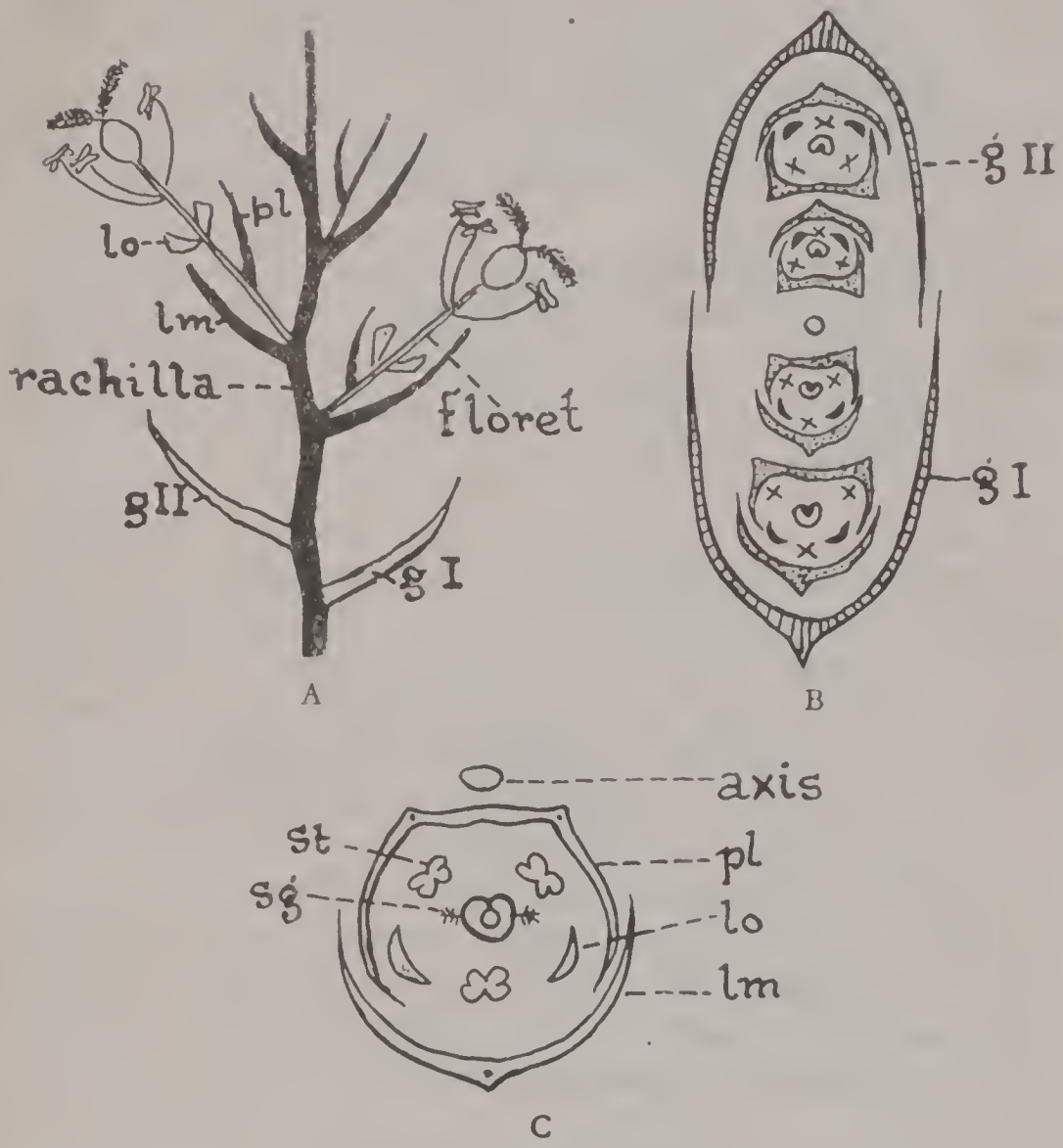


Fig. 1—GRAMINEAE

A. A representative spikelet of grass; gI, first empty glume; gII, second empty glume; lm, lemma; lo, lodicules; pl, palea. **B.** Floral diagram of a spikelet. C. Floral diagram of a typical flower; st, stamen; sg, stigma.

Flower (floret): Actinomorphic or zygomorphic; sterile, unisexual or more frequently bisexual; incomplete, bracteate, hypogynous and frequently protogynous.

Perianth: Reduced to very small succulent scales known as *'lodicules'* present at the base of the flower, 3 in bamboos and 2 in all other tribes. The lodicules are hygroscopic and swell on absorbing moisture, this helps the opening of flowers

and is followed by the exsertion of stamens and stigmas. There is some controversy regarding the acceptance of lodicules as representative of two of the three leaves of a reduced perianth and it seems more probable that they really represent a second bracteole and that the flower is perfectly naked.

Androecium: Stamens 3, usually in one whorl, rarely of two members, sometimes with a second inner, alternating whorl; anthers 2-celled, basifixed but appear versatile and pendulous; filaments long.

Gynoecium: Monocarpellary; ovary superior; styles usually 2; stigmas feathery and laterally exserted; ovule basal, erect, anatropous (slightly campylotropous), sessile on the ventral suture, with micropyle pointing downwards.

Floral Formula: $\perp\ \varsigma\ Br_2\ Brl_2\ P_{lod\ 3\ or\ 2\ or\ 0}\ A_{3\ or\ 6}\ \underline{G_1}$

Pollination: Closed self pollinated (cleistogamous) or cross pollinated by anemophily. The anemophilic nature of pollination in grasses is due to their powdery, light pollens which are easily carried by wind and caught by the feathery stigmas. The flowers do not possess nectaries, scent or colour which are essential for entomophilous pollination.

Fruit: Usually a caryopsis, i.e., an achene whose pericarp is completely fused to the seed coat.

Seed: Albuminous, embryo outside the copious endosperm in front at its base, with its one cotyledon (scutellum) completely enwrapping the radicle and plumule like a shield towards the endosperm; radicle and plumule well developed—the radicle is towards the lower end of the fruit.

Vegetative Characters

Habit: Usually herbs but shrubs and arborescents are not rare; annual, biennial or mostly perennial.

Germination: Hypogeal where the seed remains burried in the soil. During the process of germination, the radicle makes its way through the lower short, collar-like end of the sheath, called the root-sheath or coleorhiza and grows downwards while the plumule breaks through the upper distinct, cylindrical portion of the sheath, called the plumule sheath or coleoptile and grows upwards. According to some, the primary root developed from the radicle soon perishes and is replaced by a cluster of fibrous roots arising from the basal nodes of

the stem while others believe that the primary root functions throughout the life of the plant and is functional only in respect to the mother shoot.

Root: Three kinds of roots are visible: (a) seminal or primary roots, (b) adventitious or secondary roots, and (c) brace or prop roots. Externally the root system appears to be principally adventitious fibrous, branched and comparatively shallow. Many are modified to rhizomes for their perennial succession.

Stem (or **Culm**): Herbaceous (rarely woody); strong or weak; erect, prostrate or creeping, with distinct nodes and internodes; internodes typically hollow or may be solid (e.g. sugarcane, maize), always closed at nodes; the latter often swollen, terete (rarely flattened or angled). Branches arise generally from the lower nodes and thus often give rise to a tufted habit (tillering), while on the main stem there occurs no branching, although axillary buds frequently exist on each node. These nodes serve to erect the stem, if it has become bent down the lower side of the node elongates rapidly, the stem bends up and becomes erect.

Leaf: Simple, alternate, solitary at the node, exstipulate, distichous (phyllotaxy $\frac{1}{2}$), differentiated into leaf blade or lamina, sheath, ligule and auricle. Blade: usually long, narrow, linear to lanceolate with parallel venation, rarely with a constricted petiole as in bamboo. Sheath: enveloping the culm or internode lying immediately above the node to which the leaf is attached and overlapping or sometimes connate by its margins to variable length forming a slit on the side opposite to the leaf or sometimes tubular. Ligule: present as a membranous structure at the junction of the lamina and sheath and is fringed with hairs; the ligule (rain guard) functions as a protective structure preventing rain, dust, insects etc., from entering and accumulating within the sheath. Auricles: these are small membranous outgrowths from the base of the lamina, sometimes clasping the stem when well developed.

The leaves of grasses often show typical xeromorphic habits with sunken stomata which are usually covered with hair and the presence of a series of specially modified epidermal cells called *'motor cells'*, along the upper side of the leaf situated in the furrows. Due to these motor cells the leaf rolls from the margin towards the midrib under excessive trans-

piration or in dry air, enclosing the stomata completely within and checking transpiration; the lower surface which thus becomes the outer, is covered with thick-walled cells and has a few or no stomata. When the conditions favouring excessive transpiration are removed or the air becomes moist, the leaf unrolls and is brought to normal.

Economic Importance: There are very few other families which can rival the economic importance of Gramineae. The cereal grasses and millets provide food to a large proportion of the earth's inhabitants (wheat, barley, oats, paddy, corn, millets); many are valuable fodders or hay for domestic animals (pasture grasses, millets, corn etc.). A number of graminaceous crops form the main raw materials for various industries—sugar (sugarcane), paper (bamboos and grasses), starch (corn), alcoholic products and beverages (rice, rye, barley, corn, molasses from sugarcane). A few species are notable for supplying many of our household requisities (ropes and mattings from *S. munja* and furniture from bamboos), and shelter and building materials (thatch and bamboo framing). More than 80 genera are now known to be cultivated domestically as ornamentals while a few are important oil yielders (*Andropogon squarrosus*—KHAS) and some are of medicinal importance (*Cymbopogon sp.—lemon grass*).

CLASSIFICATION OF IMPORTANT GRAMINACEOUS CROPS*

I. **MAYDEAE:** Male and female flowers in separate inflorescences.

Genus: **Zea** (*Z. mays* or maize).

II. **ANDROPOGONEAE:** Spikelets bisexual or male and female side by side in the same inflorescence.

Genera: (*a*) **Saccharum** (*S. officinarum* or sugarcane).

(*b*) **Sorghum** (*S. vulgare* or grain sorghum).

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* This usual convention of botanical classification has not been followed in describing the genera and species. Crops are arranged according to their economic importance and information available.

III. **PANICEAE:** Similar as II but the inflorescence is different, spikelets falling singly from the twigs of a panicle or unjointed spike-axis.

Genera: (*a*) **Panicum** (*P. miliaceum* or common millet).

(*b*) **Setaria** (*S. italica* or Italian millet).

(*c*) **Pennisetum** (*P. typhoideum* or pearl millet).

IV. **ORYZEAE:** Involucral glumes minute, stamens usually six, all fertile.

Genus: **Oryza** (*O. sativa* or paddy).

V. **AVENEAE:** Panicle inflorescence, involucral glumes exceed the flowering glume.

Genus: **Avena** (*A. sativa* or oat).

VI. **HORDEEAE:** Spikelets in two, or rarely more, opposite rows, forming a symmetrical rarely one sided spike.

Genera: (*a*) **Triticum** (*T. vulgare* or wheat).

(*b*) **Hordeum** (*H. vulgare* or barley).

Genus: **Triticum**

The genus Triticum includes 15 species of different kinds of wheat, many of which are cultivated and found more abundantly in the Mediterranean Europe and West Asia, characterised by having spikelets 2–5 flowered, in a dense spike.

The plants are annual or perennial grasses with flat leaves; spikelets sessile, distichously in the spike form with their sides opposite to the articulate or inarticulate rachis, solitary in the cavities. Glumes rigid, often unequal sided; I and II empty glumes are obtuse or shortly awned, few nerved, persistent; flowering glume oblong or swollen at the base, dorsally rounded or keeled above, awnless or 1–3 awned, 5–9 nerved, lateral nerves not joining with the central; palea with ciliate keels: lodicules entire, ciliate. Stamens 3. Styles very short. Grains are grooved ventrally, often hairy, free or adhering to the palea.

It is said that the different forms of wheat being cultivated at present have arisen from the spelt wheat (*T. aegilopoides*) and EmMmer wheat (*T. dicoccoides*), natives of the Balkan Peninsula and Syria. These forms vary widely in the denseness of the spike, presence or absence of awns, colour of the

grain, and the extent to which they are covered by the glumes, the presence or absence of joints in the rachis etc.

Classification of wheats grown in India:

The proper classification of wheats that are cultivated in different parts of the earth, is indeed a complex problem. Opinions differ amongst botanists regarding its detailed classification, although there is, however, a consensus of opinion regarding the initial divisions.

There are three main groups:

Group I or *Einkorn group,* Group II or *Emmer* group and Group III or *Bread* or *Vulgare group.* This classification is based mainly on chromosome numbers (2n=14, 28 and 42 respectively for Group I, II and III). It is also observed that pollen grain size and susceptibility to certain diseases also markedly differ within these groups.

India grows manly five species of wheat:

(a) *T. dicoccum* Schubl.
(b) *T. durum* Desf.
(c) *T. turgidum* Linn. } Emmer group (2=28)

(d) *T. sphaerococcum* Perc.
(e) *T. vulgare* Host. } Bread or Vulgare group (2n=28)

(a) *T. dicoccum* Schubl. (Emmer wheat): One of the ancient wheats known to have been derived from *T. dicoccoides* (wild), possesses a high degree of resistance to rust. It is bearded; spikelets two grained; grains reddish, narrow, pointed at both ends and the texture is flinty or semiflinty.

(b) *T. durum* Desf. (Durum or Macaroni wheat): It is the second most cultivated wheat of India, cultivated throughout the wheat producing tracts. Ears are long; usually bearded with long awns; grains amber or reddish coloured, long, narrow, hard and more or less pointed at both ends.

(c) *T. turgidum* Linn. (Rivet or cone wheat): This wheat is not of much commercial importance. Ears usually bearded with long stout awns, commonly deciduous; grains large, plump and somewhat short with truncate apex and high dorsal hump behind the embryo and the texture is mealy, some times flinty or semiflinty.

(d) *T. sphaerococcum* Perc. (Indian dwarf wheat): This species is regularly cultivated in India, although much limited. The ears are short and compact, bearded or beardless.

(e) *T. vulgare* Host. (Bread wheat): By far the most important wheat grown in India. Ears bearded or beardless with shorter awn as compared to other cultivated wheats of India. Grains are much varied, usually plump with bluntish apex and rounded on dorsal side without prominent hump or ridge; texture flinty or mealy.

Triticum vulgare Vill.

Hindi: GEHUN *English*: Wheat

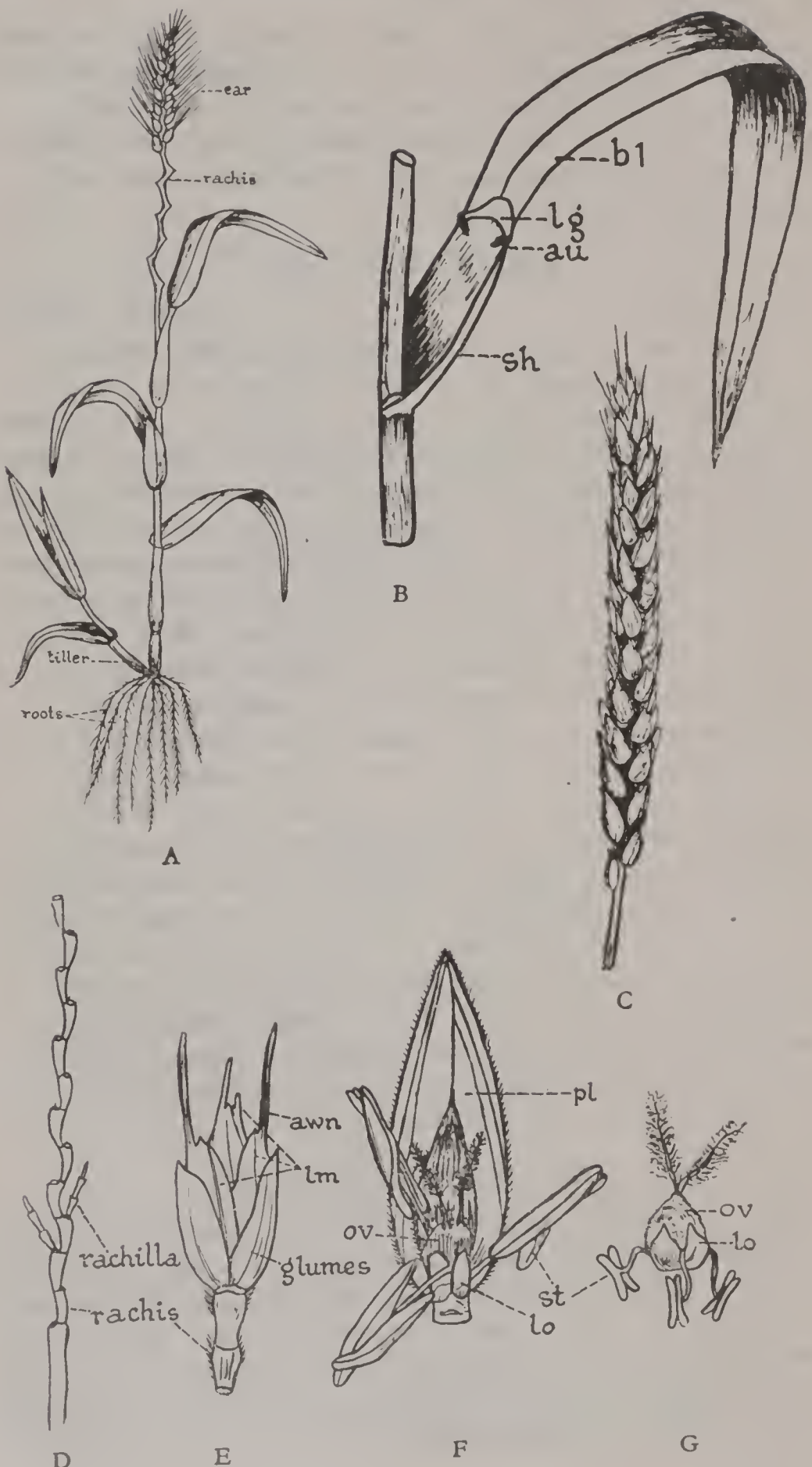
Bread was long ago called the staff of life. Among the world's great foodstuffs, none are so important as wheat and rice. Wheat provides the source of raw material for a number of industries connected with food production—that of baking, milling, and the preparation of macaroni, spagheti etc. It has a double requirement of a cool, moderately moist formative period and a warm sunny period of ripening hence the optimum climatic condition is fulfilled by the mediterranean region. The cultivation of wheat began in Asia and Africa probably 4000 years before the Christian Era. Until the early part of the present century, it was supposed that no wild wheat existed but recent investigation has proved that in the highlands of Syria and Palestine there does exist a wild wheat, a real Emmer.

Wheat avoids lands of heavy summer rain but it grows well in the temperate zone as spring or summer crop and is remarkably cosmopolitan in distribution. Its cultivation in India and China dates back to pre-historic times and its origin is still a disputable question. In India, it occupies nearly 27 million acres and thus forms the most important crop next to rice. Of the various states, U.P., Punjab, Madhya Pradesh and Rajasthan stand foremost in order of merit in the production of wheat, totalling nearly to a million tons as the annual production in this country.

BOTANICAL DESCRIPTION

Habit: A tufted annual grass cultivated in winter in India.

Root: The root system, although as a whole is adventitious and fibrous, can be divided into two types—the primary or seminal and the secondary or adventitious. The primary root develops from the grain and hence it is visible only with the main shoot while the secondary or adventitious roots develop later from the upper nodes and are found to be present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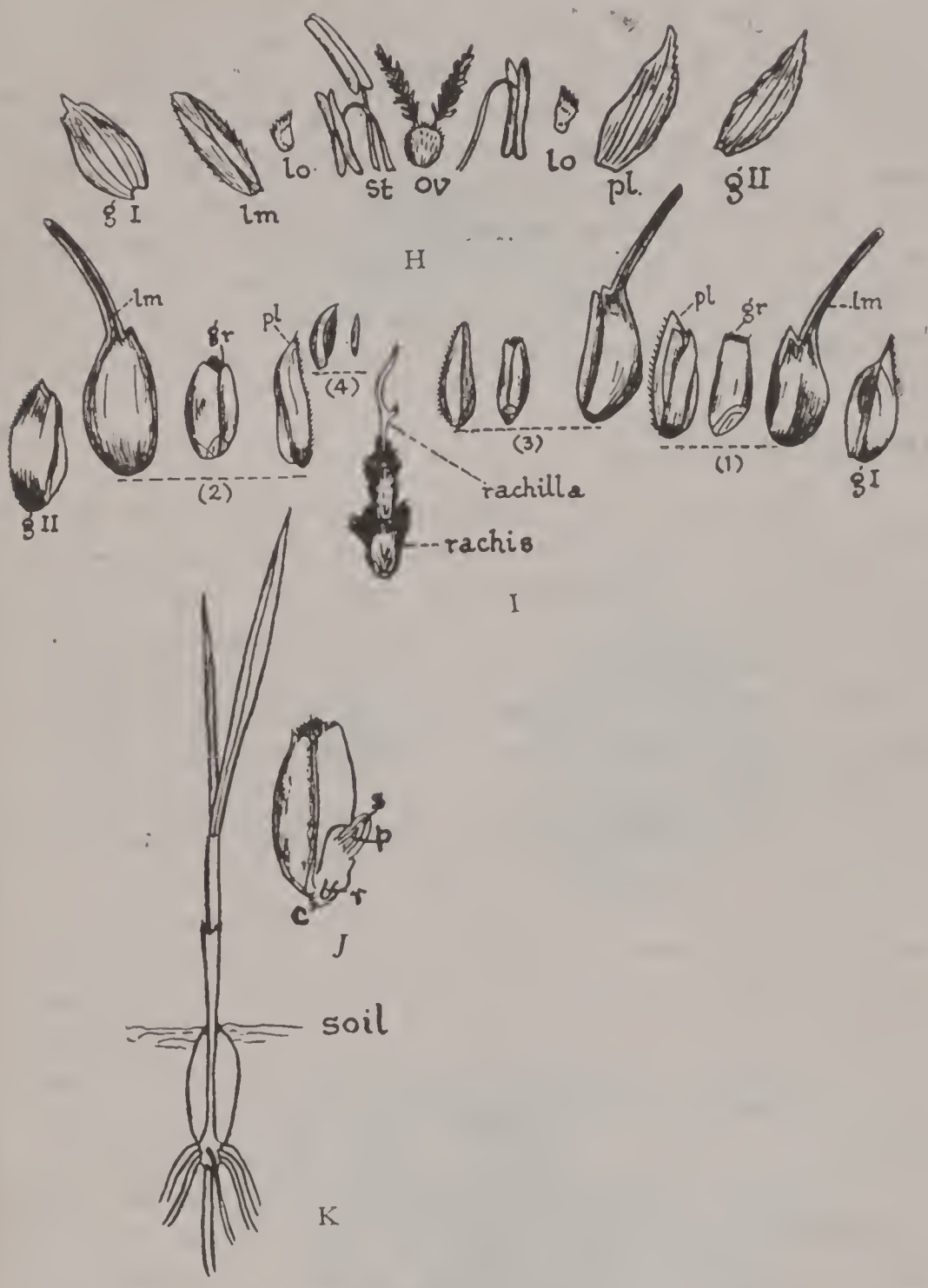


Fig. 2—WHEAT

A. Wheat plant (diagrammatic). **B.** Wheat leaf showing blade (bl), sheath (sh), ligule (lg) and auricle (au). **C.** Wheat spike or ear. D. Rachis of the inflorescence showing rachilla. **E.** A single spikelet; lm, lemma. **F.** Longitudinal section of a flower; lo, lodicule; pl, palea; st, stamen; ov, ovary. **G.** A single flower with lemma and palea removed. **H.** A dissected floret of wheat; gl, first empty glume; gII, second empty glume. **I.** A dissected spikelet of wheat; (1), (2), (3), (4) are the respective first, second, third and fourth flower, at maturity. **J.** Longitudinal section of a wheat grain at the beginning of germination; c, coleorhiza; p, plumule; r, radicle; s, germ sheath. **K.** A newly germinated wheat seedling.

both with the mother shoot as well as with the tillers. In this way, a large number of secondary roots are produced. The adventitious roots are thicker than the seminal. They are at first unbranched and covered almost throughout their length with root hair. Later, numerous lateral rootlets appear and with their development, the root-hair disappear, except towards the tip, and the roots themselves get thinner and brownish. The primary root chiefly serves the central axis of the plant while the adventitious roots mainly function in relation to the tillers.

Anatomy of the Root :

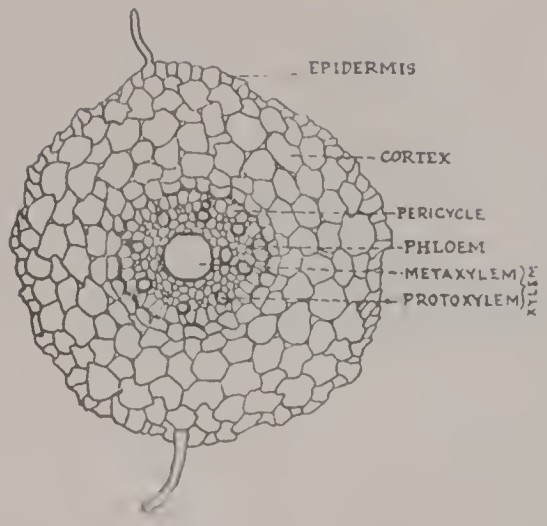
1. *Piliferous Layer or Epiblema or Epidermis*: This is present only in young seminal roots and is the outermost layer consisting of thin elongated cells, many of them developing into root hairs. As the root ages the piliferous layer dies off and the outer layer of the cortex (the tissue below epiblema) becomes suberized and forms the *exodermis* which acts as a protective tissue. A few layers of cells just below the exodermis get thick-walled.

2. *Cortex*: This consists of many layers of parenchymatous cells with intercellular spaces.

3. *Endodermis*: In young seminal roots this is in the form of a single layer of unbroken closely fitting cells, situated at the inermost layer of cortex in the form of a ring around the stele. The outer wall of these cells is thin while the inner wall is somewhat thickened and the radial walls are also slightly thickened. As the plant matures this becomes, however, more persistent.

4. *Vascular Cylinder*: (a) Externally the vascular cylinder constitutes the *pericycle* which develops a zone of sclerotized tissue and affords some protection to the inner tissues. (b) *Vascular bundle*: Xylem strands are 7-8 in number, phloem is scanty and consists of a few cells arranged alternately with the xylem strands. (c) *The ground tissue of the stele*: This consists of moderately thick walled parenchymatous cells in young roots but becomes sclerotic with age.

Stem: Erect and herbaceous, cylindrical, glabrous; with distinct nodes and internodes; nodes solid and thicker, internodes fistular; lower internodes shorter while the internode bearing inflorescence is the longest. The lowermost axillary



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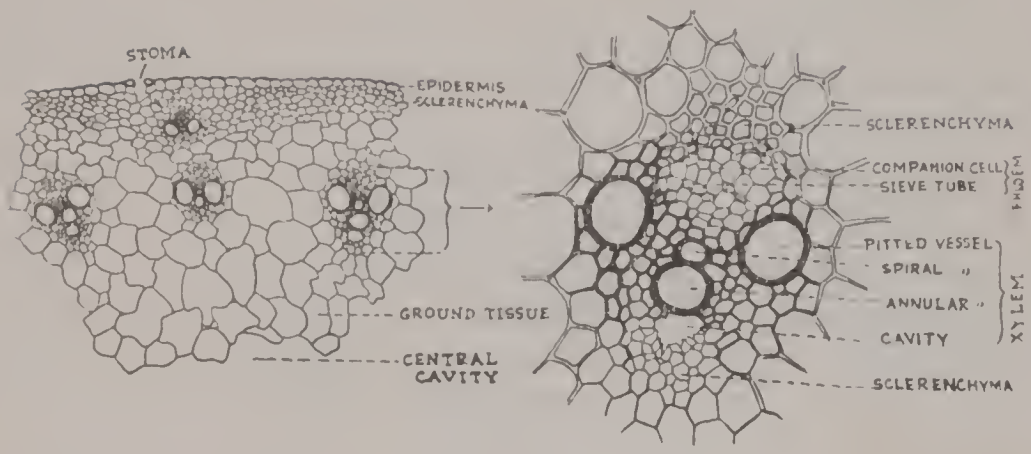

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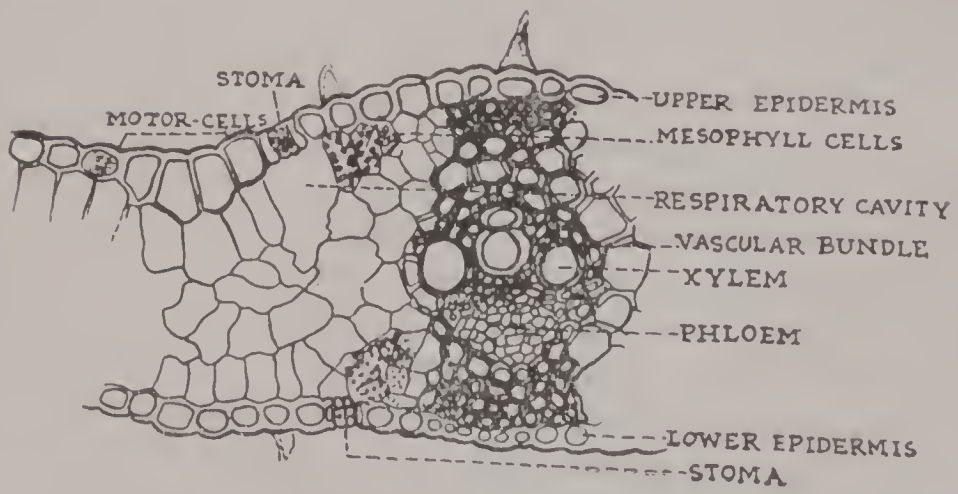

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Fig. 3—**ANATOMY OF WHEAT PLANT**

A. Transverse section of the primary root. **B.** Transverse section of the stem. **C.** Transverse section of a small portion of the leaf through a large vascular bundle (vein).

buds present at the crowded nodes at the ground level or just below the ground develop into branches, this is called *tillering*, thus making the plant typically tufted. Tillers grow alike the main stem. Buds may form on the axils of the leaves but do not form branches, thus the aerial shoots possess no branching. Lodging is often observed in varieties possessing weak straw, especially on heavy ground. It occurs at a late period of growth and brings about heavy losses both in quality and quantity of the crop.

Anatomy of the Stem:

Five distinct tissues may be recognised:

1. *Epidermis*: These are narrow elongated cells with short square cells intercalated at intervals. The walls are much thickened and pitted. Exposed surfaces are covered with a cuticle that might be coated with waxy material. Stomata are sometimes present.

2. *Hypodermis*: A few layers of thick sclerenchymatous mechanical tissues lie below the epidermis.

3. *Chlorophyllous Tissue*: This is composed of delicate parenchymatous cells embedded in hypoderm and gradually thinning out as they pass downwards below the leaf sheaths. This is in communication with the atmosphere through the stomata and is loosely packed below each stoma.

4. *Ground Tissue*: Composed of polygonal or rounded thin walled parenchymatous cells, extend from the hypoderm to the centre and is finely pitted. At the lower internodes. they might become thickened and lignified.

5. *Vascular Bundles*: These are of closed collateral type. The bundles situated within the hypoderm are smaller, closer and numerous, alternating with the bands of chlorophyllous tissues while those near the centre are embedded in the ground tissue, larger and more or less in regular rings. The bundles are almost completely surrounded by a sheath of sclerenchyma and somewhat oval in general outline.

The vascular bundle primarily consists of phloem and xylem. (a) *Phloem*: This occurs towards the exterior, between and beyond the Y- or V-shaped open limbs of xylem. It is exclusively composed of sieve-tubes with their companion cells. The outermost portion of the phloem is called *protophloem* (a broken mass) and the inner phloem is called *meta-*

phloem. The former soon gets disorganised and the latter shows distinct sieve tubes and companion cells. (b) *Xylem*: This consists of four distinct vessels arranged in the form of Y or V and a number of smaller vessels irregularly arranged. The smaller ones lying towards the centre (*annular* and *spiral*) form the *protoxylem* and the two bigger vessels together with the tracheids lying in between form the *metaxylem*. A few vessels of the former that lie towards the inner side break down with age and give rise to a conspicuous water containing cavity.

Leaf: The leaf consists of the lamina or blade with the sheathing base, ligule and auricles. *Lamina* (or blade): simple, long, narrow, margin entire and slightly twisted, rough, the two halves divided by the midrib are unequal—one side being longer and narrower than the other, apex acuminate, venation unicostate parallel. *Sheath*: encircles the internode giving it a thickened appearance, thicker than the blade, membranous margin, glabrous or hairy, entire below but split above-opposite the side to which the leaf blade is attached. *Ligule*: present at the junction of the sheath and the lamina—thin, membranous, colourless, free margin irregularly cut and fringed with minute hairs. *Auricles*: small, attached to the base of the lamina, loosely clasp the stem and are hairy. Phyllotaxy alternate ($\frac{1}{2}$); ptyxis convolute in bud.

Anatomy of the Leaf :

Wheat leaves are of isobilateral type (they being nearly erect, are equally illuminated on both sides). Histological studies of the wheat leaf reveal three distinct tissues:

1. *Epidermis*: This is a continuous covering for the leaf from both sides except where broken by the stomata. The number of stomata is more on the upper surface (10:7) and are slightly sunken below the surface. Each stoma has a large respiratory cavity underneath, two narrow enlongated guard cells, and two small sister guard cells on either sides. The lower epidermis is flat and the cells are somewhat similar throughout. The upper epidermis consists of more diversified cells and is ridged. A series of specially modified larger epidermal cells called *"motor cells"* are situated in the furrows while the ridges contain vascular bundles underneath and the cells are elongated, thick-walled and pitted often alternating with hairs. On the leaf margins, the epidermal cells have specially thick

sinuous walls. The epidermis of the sheath is somewhat modified and the cells are in rows, elongated, sinuous and much thickened.

2. *Leaf Parenchyma*: These are the mesophyll tissues and consist of spongy parenchymatous cells, in which the green chloroplasts are evenly distributed. This extends from the upper to the lower epidermis.

3. *Leaf Vascular Bundles*: The structure of the leaf vascular bundle is similar to the stem bundle. The bundles are collateral—xylem above and phloem below. Each bundle has an inner and an outer sheath which are normally colourless. The arrangements of the annular and spiral vessels, elliptical pitted vessels, sclerenchyma and other tissues are similar to that described in the stem vascular bundle.

Inflorescence: The inflorescence or 'ear' is a compound spike of sessile spikelets placed singly at each notch of the zigzag rachis. The rachis is articulated and each internode of the rachis is narrow at the base and broader at the apex; one side concave and the other convex; margin ciliate and the spikelets face the concave side of the internode. Spikelets are generally arranged in two alternating rows forming distichous spike, they are compressed, parallel to the rachis, closely or loosely imbricate, one or more of the upper ones are always abortive. Spikelets contain two glumes and 3–5 florets of which the lateral flowers are fertile and the central usually sterile. Glumes I and II enclosing the inner florets, boat-shaped, broad, margin membranous, keel prominent, base round and glabrous, 5–9 nerved which are not joining with the central, are empty and usually have but a short awn or blunt apex. The lower spikelets of the ear are often sterile even in the best selected varieties. The inflorescence is enclosed in the sheath of the terminal leaf and each shoot (main and tillers) ends in an 'ear' or spike. The spike may be glabrous or hairy, awned or awnless depending much on the variety. Sterility in ears gravely affects the yield ranging from partial to complete sterility. This may be a hereditary constitution, characteristic of a variety or may be caused by adverse environmental conditions.

Flowers (*Floret*): Bisexual, incomplete with a perianth and two bracteoles or fertile glumes. The fertile glumes are respectively called *'lemma'* and *'palea'*, which envelop the essential organs of the flower. Lemma is boat-shaped

with several nerves but no distinct keel and possesses a long or short barbed awn with teeth rising along the angles. Palea is of the same size as the lemma, thin, membranous, situated opposite the lemma, with two prominent lateral nerves, keeled and generally not possessing awn.

Perianth: Represented by two small, thin, papery bodies called 'lodicules' that are truncated on the side of lemma and face the palea; margins are hairy.

Androecium: Stamens 3, odd stamens interior; anthers versatile and pendulous, linear and bicelled; dehiscence introrse filaments short when young but long and protruding while flowering.

Gynoecium: Carpel 1; ovary superior, unilocular, ovate, hairy on top; styles 2 with bushy stigmatic surface which is short and never protruded; ovule single and basal, anatropous.

Floral formula: † ☿ Gl_2 Lm_1 Pl_1 $P_{lod\,2}$ A_3 $\underline{G_1}$.

or, † ☿ Br_2 Brl_2 P_2 A_3 $\underline{G_1}$

Pollination: The opening of flowers occurs in sequence of their origin (from the bottom towards the top) on the ear and the anthesis is helped by the hygroscopic behaviour of the lodicules. Self pollination is the rule but cross pollination by anemophily also occurs in certain varieties.

Fruit (or grain): Caryopsis, pericarp fused with testa, usually three in each spikelet—the two lateral ones larger than the single terminal one; in shape they are oblong, swollen (more or less according to the quality); the dorsal surface smooth and round, white, yellowish while the ventral surface with a central groove mark the place of attachment to the ovary. The grain is usually blunt at both ends or pointed, top broad, surrounded by a hairy tuft. The colour of the grain been white, yellow, red or brown.

Seed: Albuminous with single cotyledon.

Germination: Hypogeal. Utilization of the reserve food (endosperm) during the process of germination, is done by the activation of the enzymes diastase and cytase which render the insoluble starch soluble and diffusible, the energy utilized by the growing radicle and plumule.

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Genus: **Hordeum**

Hordeum comprises of 20 species which are more or less found in the temperate regions (including the various barley grasses) a number of them are cultivated. The characteristic feature of the genus is, that the spikelets are in groups of three on the main axis, forming a dense spike. Each is one-flowered when perfect, but commonly either the central or the two lateral flowers are aborted (2-rowed) and when all are fertile, developing six vertical rows of grain, the variety is known as a 6-rowed barley. In India the commonly cultivated form is the 6-rowed barley.

The plants are erect, annual, rarely perennial grasses with flat leaves. Spikelets sessile, in groups of 3, arranged on the nodes, in two or more rows on the simple inarticulate rachis, in a tangential position; the lateral spikelets of the group are often imperfect; the rachilla on which the spikelet grows laterally is prolonged and appears as a small bristle-like structure,

readily seen with a lens, lying within the 'furrow' of a barley grain; it is jointed at the base of the flowering glume and produced above it with sometimes an imperfect glume. Empty glumes—very narrow, rigid, persistent, present on the outer side of each cluster of spikelets, together often resembling an involucre and stand side by side in front of the flowering glume. The flowering glume bears the essential organs of the flower and is dorsally rounded, 5-nerved above and narrowed into an erect or recurved awn; palea 2 keeled. Lodicules ciliate. Stamens 3. Style very short. Grains grooved in front and the tip is usually covered with long weak hairs; may or may not be adherent to the palea.

The cultivated varieties of barley include—*H. vulgare* Linn. (*H. sativum* Pers.) var. *distichum* (2-rowed barley, where the central flower of each group is fertile) and var. *hexastichum* (6-rowed barley).

Diagnostic Characters of Triticum and Hordeum plants at early Stage:

1. Ligule:	Triticum	:	Developed but more or less blunt
	Hordeum	:	Developed but blunt.
2. Auricles:	Triticum	:	Developed and hairy.
	Hordeum	:	Well developed but glabrous.

Hordeum vulgare Linn.

Hindi: JAO *English*: Barley

Barley is the most ancient of all the food grains and was held sacred by the Aryan race. It still forms an important cereal of the world. It is widely distributed but more commonly grown in the temperate zone. It can grow in the hot climate as well and can stand varying degrees of moisture. Apart from its use as a cereal, a considerable amount goes to form the raw material for malt, brewed into beer and distilled into spirituous liquor. It is one of the staple crops of India and occupies about 6·8% of the total cultivated area, thus bringing the total area under it between 7-8 million acres. In India it is a *rabi* crop and is grown mainly in U.P., Rajasthan and Bihar, in which U.P. alone contributes 60% of the total produce of the country.

BOTANICAL DESCRIPTION

Habit: An erect annual herb, cultivated in India as winter crop.

Root: Both tap roots (seminal roots) and adventitious roots are visible in the early stages. The primary tap roots are later replaced by short lateral roots produced at the base of the stem from the nodes near the ground level which form a whorl of permanent adventitious roots. This is further supplemented by the tillers and ultimately it takes the shape of a dense mass of fibrous adventitious root system present at the upper soil layer. A few may penetrate deeper.

Stem: Erect, herbaceous, cylindrical, smooth with distinct solid nodes and hollow internodes, the upper longer internode carries the spike, tufted as wheat but the number of tillers are fewer, some of the varieties develop the spreading habit.

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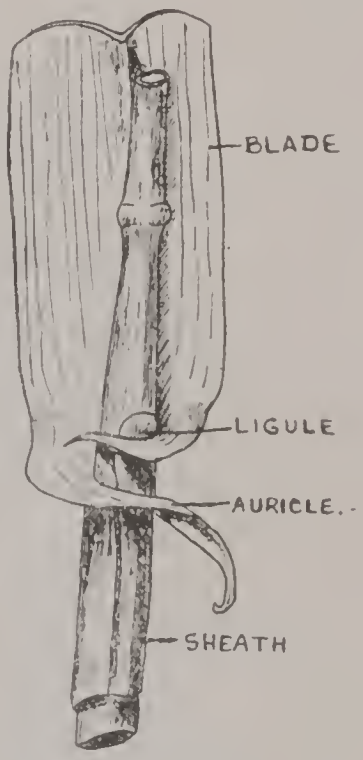

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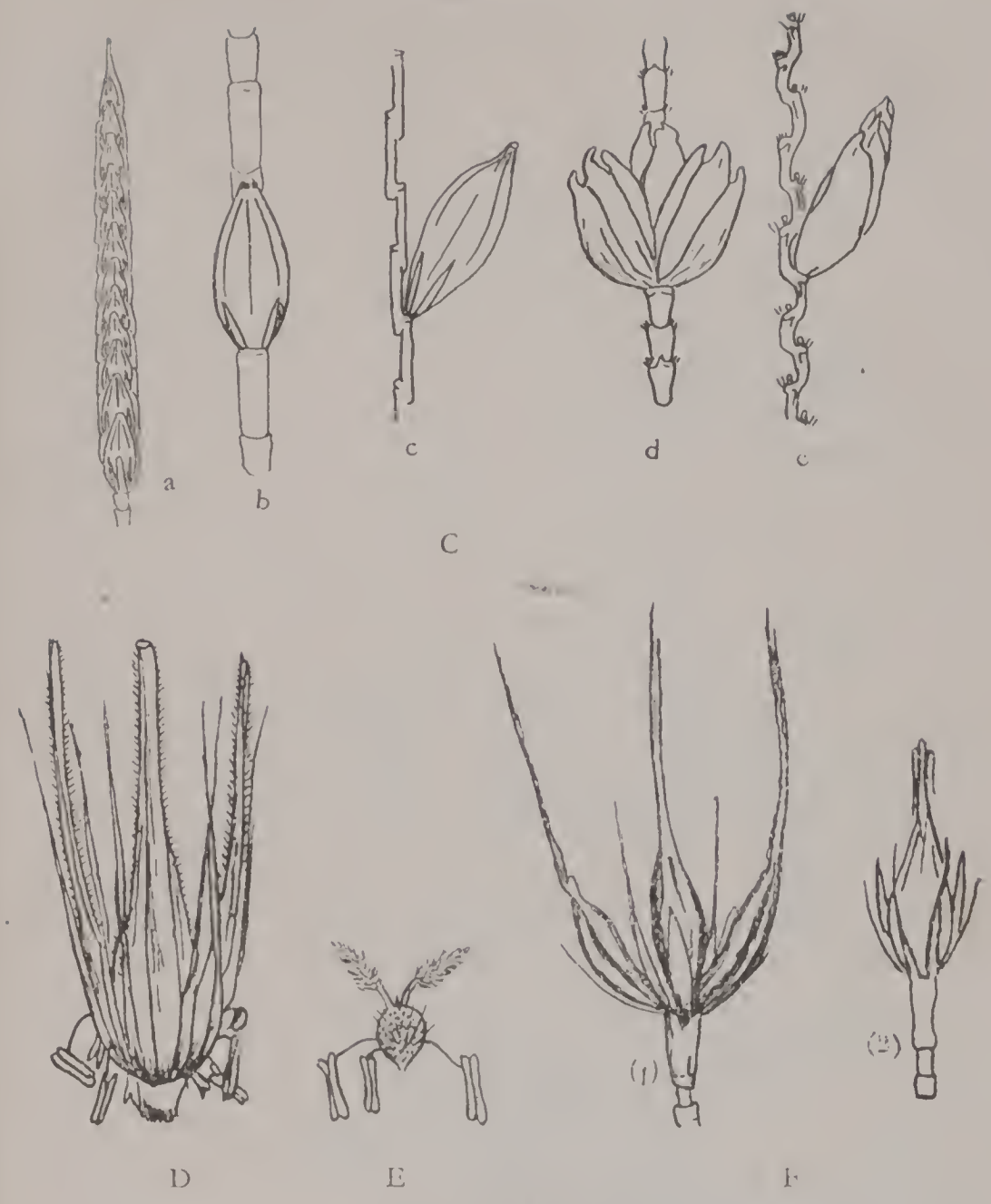

Fig. 4—**BARLEY**

A. A barley spike with a leaf. **B.** Part of stem and leaf. **C.** Barley and wheat spikes (awnless) compared; a, b, c—barley spike, spikelet and rachis; d, e—Wheat spikelets and rachis. **D.** A single spike during anthesis. **E.** A floret with lemma and palea removed. **F.** Barley spike: (1) A six-rowed variety. (2) A two-rowed variety.

Leaf: The leaves of barley resemble the leaves of wheat plant, but exhibit considerable variability in number, colour, length and width. Lamina (blade) : simple, linear-lanceolate, rounded at the base, narrow, entire margined, acute apexed, rough surface, venation parallel unicostate with sheathing base, encircle the internode. Sheath: smooth and striate. Ligule: well developed but small. Auricles: more prominent than any

other cereal, clasping and without hairs. The upper leaf twists itself round the ear and gradually unfurls as the ear emerges out.

Its habit and anatomy are very similar to that of wheat.

Inflorescence: Commonly known as *"ears"*, is terminal, borne by the mother shoot as well as by tillers. It is a racemose that consists of spike of spikelets with many groups of three single flowered spikelets arranged from top to bottom on an elongated form of rachis. The rachis is straight, inarticulated, having both sides of the internodes flat, the lower end of the internode narrower than the upper, margin ciliate strongly compressed and truncated, consists of a series of straight joints ending in flat cushions on which the alternate spikelets are inserted. Spike is two ranked with brittle axis without a terminal spikelet. Each spikelet appears practically sessile on the rachis, but a triplet of single-flowered spikelets really represents a primary branch with two opposite lateral branches each bearing one flower. The group of three spikelets is enveloped by the involucral empty glumes which are linear, subulate at the base, green, acuminate and end in a fine awn like structure or bristle. The rachilla on which the spikelet grows laterally is prolonged and appears as a small bristle-like structure, readily seen with a lens, lying within the "furrow" of a barley grain. The groups of spikelets are arranged alternately at notches on opposite sides of the rachis, so that the whole ear appears to have six longitudinal rows of flowers (3 rows on each side). The lateral spikelets are occasionally barren and rudimentary, sometimes staminate while the middle one is perfect, sessile and awned.

Flower (*floret*): Bisexual, incomplete and bracteolate—as 'lemma' and 'palea'. Lemma: slipper shaped, 5-ribbed, broad, round at the back and ending in a long barbed awn. Palea: thin and membranous, slipper-shaped, smaller than lemma and invested by it, do not generally bear awn.

Perianth: This is in the form of two lodicules, which are membranous with hairy margins.

Androecium: Stamens 3; odd stamen interior; anther versatile, bicelled, linear with introrse dehiscence, filaments short and green when young but long and protruding while flowering.

Gynoecium: Monocarpellary; ovary superior, unilocular, ovate; styles 2, terminal; stigmatic surface feathery; ovule single, basal, anatropous.

Floral Formula: $+ \oplus \, ☿ \, Gl_2 \, Lm_1 \, Pl_1 \, P_{lod2} \, A_3 \, \underline{G_1}$.

or $\dagger \, ☿ \, Br_2 \, Brl_2 \, P_2 \, A_3 \, \underline{G_1}$

Pollination: Natural crossing, however, occurs sparingly by anemophily and normally self pollinated.

Fruit or Grain: Caryopsis, the grain is adherent to the flowering glume and palea and on being thrashed does not separate from the latter. The fruit is pointed at both ends.

Germination: Hypogeal.

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Genus: **Oryza**

The genus Oryza belongs to the tribe Oryzeae that includes about 15 genera, all of which are mainly tropical with marshy habitat. The tribe Oryzea is characterised by having one-flowered spikelets, 1–3 nerved palea and frequently possesses six stamens in the androecium. The genus is characterized by the tall, annual or perennial grass-like habits with long, narrow, flat and sheathing leaves. Spikelets one-flowered, loosely arranged on the branches of an elongate panicle, disarticulate above the two lowest glumes. The two lower involucral glumes (Glumes I and II) are minute, scale like, empty and rarely absent; the flowering glume (lemma) is solitary, leathery or papery, strongly 3–5 nerved, nerves hairy, apex obtuse acute or awned; palea linear or lanceolate, as long as the flowering glume, 3–5 nerved, nerves, hairy, leathery, with membranous margin. Lodicules 2, 2-lobed, rarely entire. Stamens 6; anthers linear, all fertile. Style short, free; stigmas laterally exserted and plumose. Grain narrowly oblong, compressed, closely covered by or adnate to the lemma and palea.

Oryza includes 6 species, rice (*O. sativa*) being the most important of those which forms one of the chief food plants of the world.

Oryza Sativa Linn.

Hindi: DHAN (plant) CHOWAL (grain) *English*: Paddy (plant) Rice (grain)

The half-truth of the old adage that bread is the staff of life is perpetuated as a universal verity by the fact that the teeming millions of the orient from the tropical to the temperate zone obtain their carbohydrate from rice. Among the world's great foodstuffs, rice ranks first. The use of rice in the ancient lands of the East dates back into the unknown past. Centuries ago rice spread from China and India to Egypt and North Africa. Among the environmental factors affecting rice production, water supply is most important, the rice fields being submerged under approximately 6 inches of fresh, slowly moving water for at least 75 days. A total of 45 to 65 inches of water is generally required for rice production and it needs a mean temperature of more than 70°F during the growing seasons of 4–6 months. Hence rice is a product of the tropics

and subtropics, most of it being grown in regions of reeking humidity. It is the most extensively grown crop in India, occupying about 75 million acres and the most important states are—Bihar, West Bengal, Orissa and U.P.

BOTANICAL DESCRIPTION

Habit: A tall, cultivated, annual (a few varieties are known to be perennial also), cereal grass—cultivated as rainy or autumn season crop.

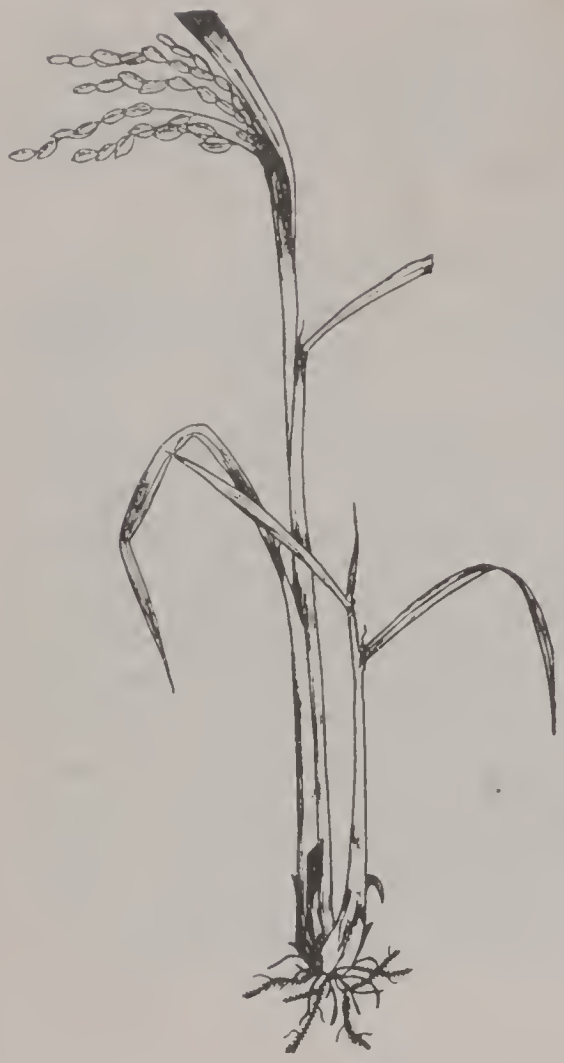
Root: On germination, the primary root, called 'seminal root' develops from the base of the grain. This is soon followed by short lateral roots, called secondary roots which arise endogenously from lower nodes of the young plant and its tillers. This in its turn gives rise to a whorl of permanent adventitious root system. In mesophytic forms, these roots develop from the nodes situated just below the ground level while in *'floating forms'* of roots they develop from the nodes above ground. In a few weeks the plant quickly develops a thick mass of adventitious fibrous root system and its density depends much on soil texture, water and air supply, manurial treatment and variety. In a few forms characteristic root colours also tend to develop.

Anatomy of the root :

In the young root there is an epidermis of thin-walled cells, more or less square in outline. Towards the apex these cells may grow out to form the root hairs. Beneath the epidermis and separated therefrom by a single layer of thin-walled cells is a single-layered exodermis of thick-walled cells. The remainder of the cylinder is constituted thin-walled parenchyma.

The study of the adaptation of paddy plants from a dry land condition to aquatic habit is very interesting and anatomical studies of paddy roots have largely explained the reason underlying this capacity to thrive in these extremes. The following account taken from Hector (1936) and Grist (1953) will give the changes that occur in the internal structure of paddy root during this process of adaptation:

"The central cylinder is at first unlignified and at an early stage develops a number of very large central vessels—either a single central vessel or six vessels arranged starwise. To



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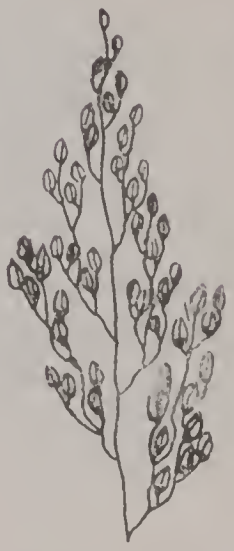

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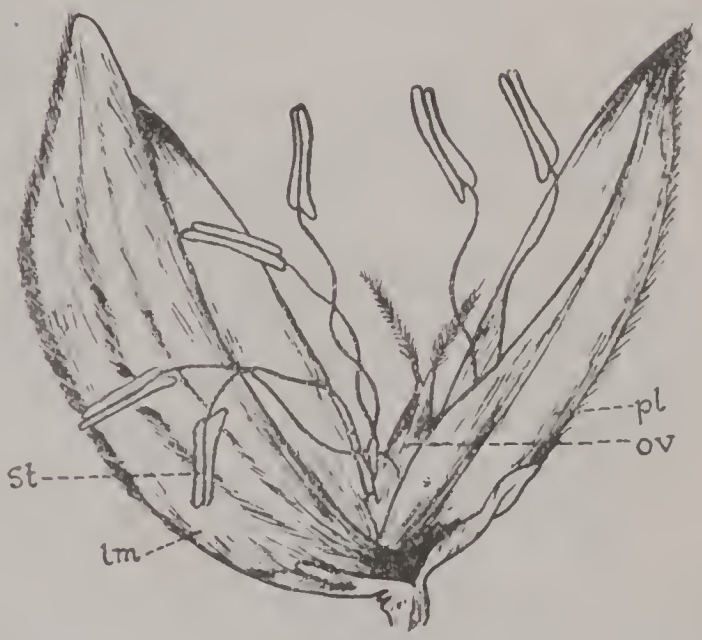

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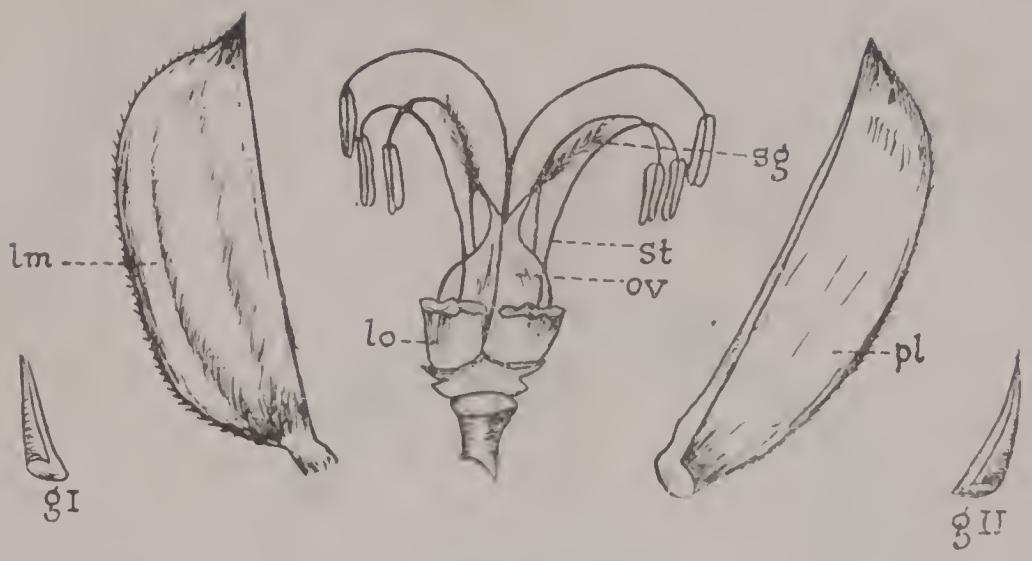

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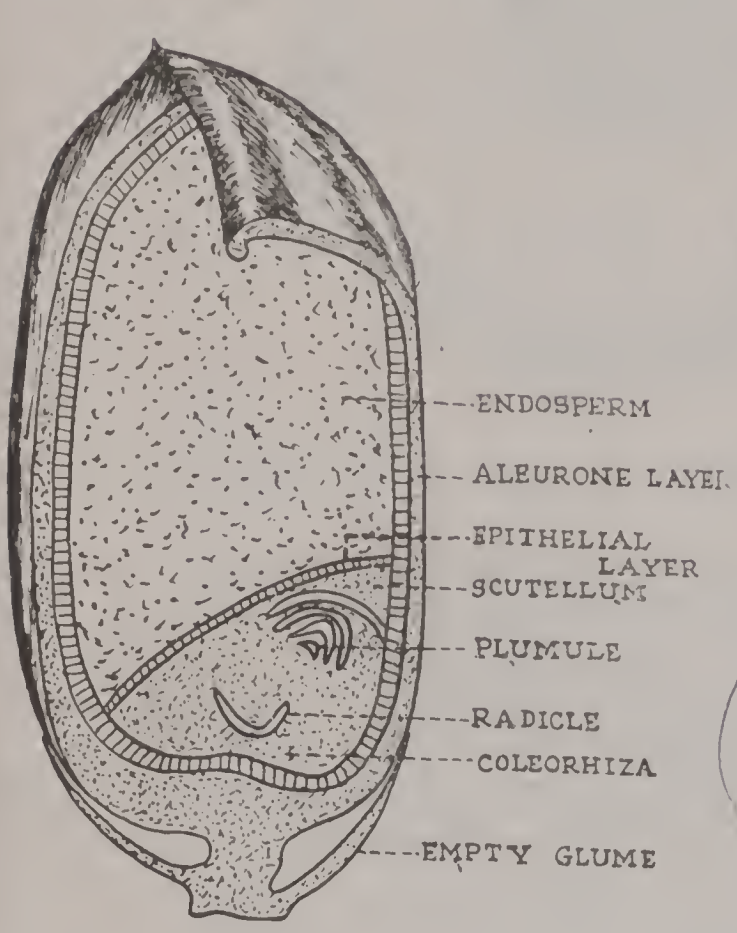

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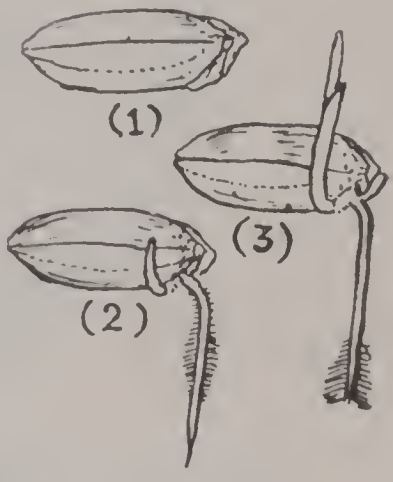

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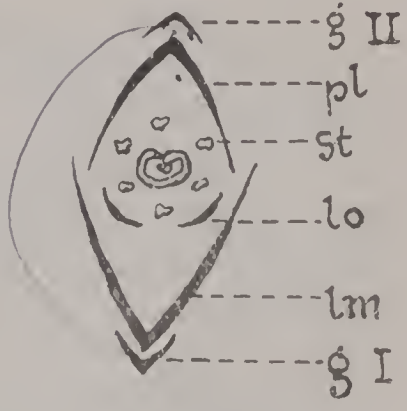

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Fig. 5—**PADDY**

A. A paddy plant with tiller and inflorescence. **B.** A panicle of spikelets. **C.** A portion of the inflorescence showing the arrangement of spikelets. **D.** A single spikelet. **E.** Spikelet dissected out; gI, first empty glume; gII, second empty glume; lm, lemma; pl, palea; lo, lodicule; st, stamen; ov, ovary; sg, stigma. **F.** Structure of the rice grain. **G.** Germination of rice grain; (1) seed, (2) stage, (3) final stage. **H.** Floral diagram (stamens introrse).

the exterior, groups of smaller vessels alternating with phloem and separated by thin-walled parenchyma, form a vascular ring. The xylem of these groups abuts on a single layered pericycle. The remainder of the cylinder is constituted of thin-walled parenchyma.

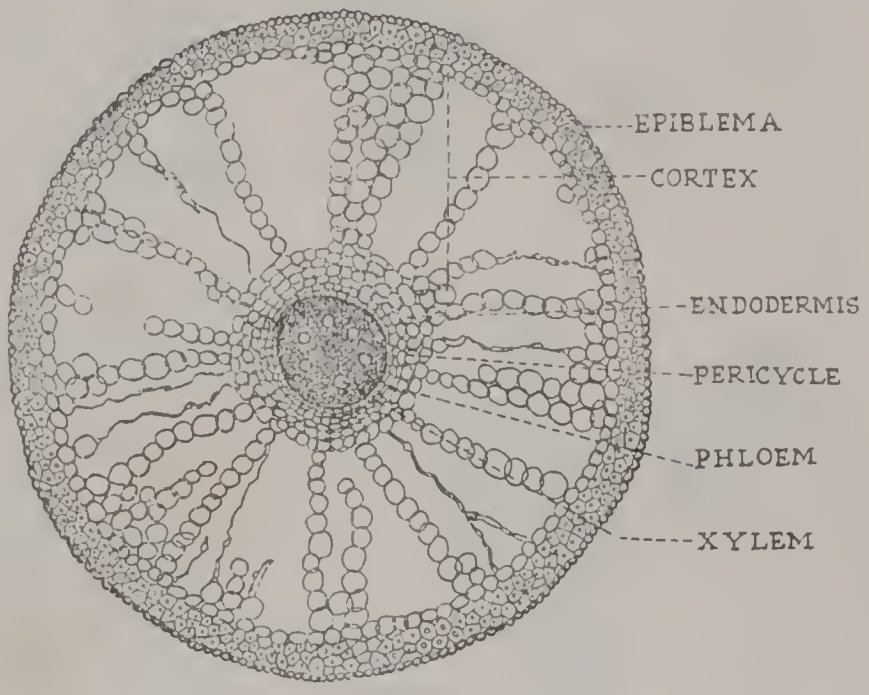

Fig. 6—TRANSVERSE SECTION OF THE PADDY ROOT

"As the root ages, the epidermis and the layer immediately beneath are sloughed and the exodermis replaces them. This layer then thickens further and its outer walls become suberized. Thickening of certain of the adjacent layers of the cortex may follow. Simultaneously, the radially arranged intermediate cells of the cortex separate from one another and alternate strands or groups of strands so formed may shrivel and die. There is thus formed a cortical structure strongly resembling that of many water plants. Adjacent to the endodermis, which gradually thickens, two or three layers of cortical cells tend to remain more or less unaltered. At maturity the central cylinder is thus invested by a loosely pleated jacket-like cortex."

"The central cylinder also becomes modified. The vessels become lignified and in time the cells of the parenchyma are strongly thickened, thus forming a solid central core to the root."

Stem: The stem is more or less erect, herbaceous, cylindrical. Nodes and internodes are distinct; nodes swollen and solid inside, while internodes uniformly cylindrical and fistular; the internodes may be green or coloured and show a tendency for the internodal lengths to increase from the base upwards. Pulvinus is present immediately above the actual node which may be either coloured or colourless, the colour is associated with the colour in the leaf sheath. Aerial branching is absent—buds may develop in the axil of each leaf of the main stem, but normaly, only the lowermost buds from the crowded nodes at ground level develop into branches, thus a typical tillered plant develops. The number of tillers developed depend on the variety, environmental and edapnic conditions. Lodging is frequently observed and that depends both on internal and external factors. Normally water-grown-forms lodge when water recedes. It also depends on nitrogen fertilization and the variety cultivated.

Leaf: The leaf of paddy consists of the blade, sheath, ligule and auricles. Blade: simple, long, narrow, entire, flat, rough, pubescent or hispid, unicostate parallel veined with a prominent midrib and the lower part extending into a sheath base; sometimes coloured and the concentration of colour is more towards the midrib. Sheath: encircling the internode from the pulvinus upwards, split to the base, finely ribbed, more or less glabrous and sometimes coloured. Ligule: white, membranous and prominently present at the junction of the sheath and the lamina with a tendency to split up when it develops. Auricles: sickle-shaped, long and slender, teeth are normally present on the convex face of each ligule.

The number of leaves borne on an axis is equal to the number of nodes and is more on the main axis. Phyllotaxy alternate ($\frac{1}{2}$).

The uppermost leaf from which panicle emerges (called 'flag leaf') is somewhat modified and different from the normal leaves. It is shorter, broader and falls from a vertical to a horizontal or dropping position with the growth of the inflorescence.

Inflorescence: A terminal panicle of spikelets borne on a long peduncle which is an extension of the topmost internode. The main axis of the inflorescence, called "rachis", bears branches out of which arise the spikelets which are actually the

units of inflorescence and are arranged singly or in pairs. The spikelets are one-flowered, attached with a short pedicel. The panicle may be close and compact or loose and spreading, depending upon the variety.

Flower (floret): Bisexual, incomplete with superior ovary. The involucral empty glumes are short, rudimentary and bristle like. Lemma: boat shaped, hard keeled, provided with five nerves which are spinescently hairy, apex solitary and pointed or prolonged into an awn. Palea: situated opposite the lemma, similar in size and texture as lemma, three nerved and may also be awned that being more infrequent.

Perianth: Represented by two small, oval, thick and fleshy bodies called 'lodicules', situated at the base of the ovary.

Androecium: Stamens 6, all of which are fertile (rare in cereals), possessing short filaments, bilobed anthers, anthers linear and pendulous.

Gynoecium: Monocarpellary, pistil with plumose stigma, bifid and laterally exserted; ovary superior, with a basal erect anatropous ovule.

Floral Formula: $\dagger \, ☿ \; Gl_2 \, Lm_1 \, Pl_1 \, P_{lod_2} \, A_6 \, \underline{G_1}$

Or $\dagger \, ☿ \; Br_2 \, Brl_2 \, P_2 \; A_6 \, \underline{G_1}$

Pollination: Self pollination is the rule, nevertheless, a variable amount of cross-fertilization may take place varying with the variety and locality. Cross pollination is through anemophily.

Fruit: A caryopsis, grains adnate to the flowering glume (lemma) and the palea, with minute empty glumes at the base.

Seed: Albuminous, with distinct scutellum.

Germination: Hypogeal and is said to possess no dormant period.

Sterility in Rice:

Sterility is well nigh universal in rice. This causes a great loss in yield. The intensity of sterility may vary from partial (presence of a few empty spikelets in the panicle) to complete sterility. Unfavourable weather and edaphic conditions, physiological conditions, inherited characters, diseases and insect attacks, are some of the important reasons of sterility and cause anther genesis or failure of fertilization.

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Genus: Zea

Zea belongs to the tribe Maydeae which is found in the tropical and subtropical regions of the world.

The genus includes the single species *Zea mays* Linn. (monotypic), much cultivated in the warmer parts of the earth and originated in tropical America. It is a tall annual, with large broad leaves monoecious and diclinous. The male inflorescence is a terminal panicle of numerous male spikes; female inflorescence is in the leaf axils subtended by spathes and grown together into a solid axis bearing double rows of flowers, the whole forming the cob; the long slender silk-like styles project in a tuft from the top of the young cob. The hard ripe grains are surrounded only at the base by the thin glumes.

Zea mays Linn.

Hindi: BHUTTA, MAKKI *English*: Maize, Indian corn.

Maize or Indian corn had long been the important food crop of ancient Maya, Aztec and Inca and of many other less civilized Indian tribes throughout the New World. It appears to have had its origin in Mexico but now it is widely cultivated in the tropical and subtropical regions of the world. The American Corn Belt, the world's greatest corn producing region, has an average temperature of 70° to 80°F, an average night temperature exceeding 58°F, and a frostless season of more than 140 days. Virtually no corn is grown where the average summer is less than 66°F, or where the average night temperature falls below 55°F. For optimum growth and grain production, corn needs a plentiful supply of moisture, well distributed throughout the growing season, the maximum yields being obtained where there is a monthly rainfall of 3 to 6

inches during June, July and August. Corn is now produced from 58°N. Lat. to 40°S. Lat. It is grown below sea level and at elevations of over 12,000 ft. It requires fertile loamy soil. According to the degree of importance, maize gets the third position in India, next to that of wheat and rice. The Indo-Gangetic plain produces 75% of the total output of India, with U. P. and Bihar having the maximum contribution. It is produced both for human consumption and fodder but in India it is mainly a food crop.

BOTANICAL DESCRIPTION

Habit: An annual cultivated herb, tall, stout and grown during the rainy season. The plant is monoecious and bearing male and female spikelets in separate inflorescences.

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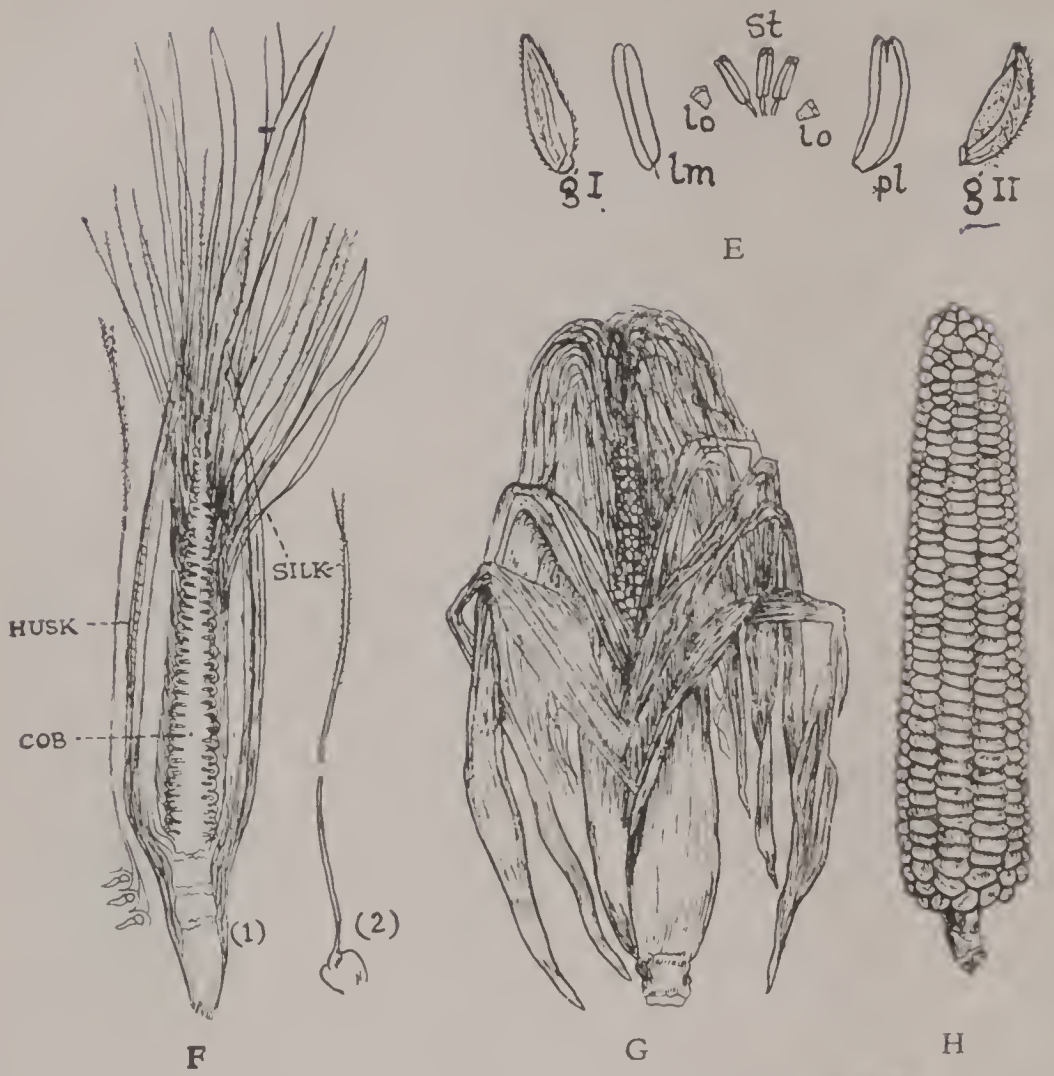
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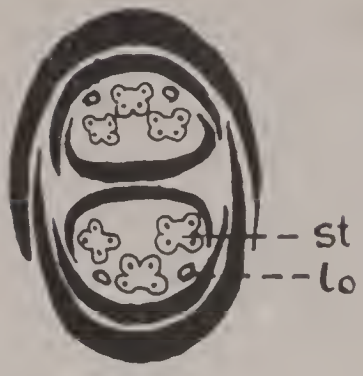

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Fig. 7—**MAIZE**

A. A maize plant showing male inflorescence at the top and the axillary female inflorescence (spadix). **B.** A pair of male spikelets (one sessile and the other pedicIled). **C.** A. spikelet during anthesis. **D.** Longitudinal section of a maize floret. **E.** A male spikelet dissected out (showing one floret): gI, first empty glume; gII, second empty gume; lm, lemma; pl, palea; lo, lodicules; st, stamen. **F.** (1) Diagram of longitudinal section of the ear bearing branch. (2) Pistillate flower from a young ear. **G.** Pistillate spike or spadix (ear). **H.** A ripe cob. **I.** Longitudinal section of a maize grain: 1, seed coat; 2, aleurone layer; 3, endosperm; 4, epithelial layer; 5, scutellum; 6, coleoptile; 7, plumule; 8, radicle; 9, coleorhiza. **J.** A germinated maize grain. **K.** Floral diagram of a male spikelet.

Root: Corn possesses three kinds of roots: (a) seminal, primary or temporary roots, (b) adventitious, secondary or permanent roots, and (c) prop or brace roots. Seminal roots are produced from the tip of the kernal when it first sprouts up and may be branched after a few days. Some authorities opine that these are temporary roots and persist only for a few weeks and later are replaced by the permanent adventitious root system while others conclude that they function throughout the life of the main plant or mother shoot. The adventitious roots come out in whorls from the stem nodes near the ground level and are shallow in depth. They grow horizontally to some distance and then bend abruptly downwards and go to a maximum depth of about 4 feet. All the roots, especially those near the surface are branched and coloured, the colour is either brown or white depending on the age. Prop or brace roots serve as anchorage to the tall maize plant and come out in whorls from the lowest nodes lying at the bottom of the culm near the ground level. They are thicker than the normal roots, often deeply pigmented, surface somewhat mucilaginous and with well developed

sclerenchyma. On entering the soil they behave as ordinary roots.

Anatomy of the Root: The anatomy of the matured corn roots shows similar structures as described in wheat with the presence of: (a) hairs, (b) epidermis or exodermis, (c) cortex, (d) endodermis, (e) pericycle, (f) phloem, (g) xylem, (h) trachea and (i) ground tissue.

Stem: Aerial, erect, solid, with distinct nodes and internodes; stem thickened at the base of the nodes; internodes smooth, enclosed by leaf sheath, furrowed, furrow lying opposite the side to which the leaf is attached, lower internodes shorter, thinner and slightly pigmented, upper internodes longer but thicker, becoming gradually thinner again upwards till tapering to the tassel with the longest top internode. Buds develop from the nodes at the axil of each leaf but these fail to develop from the lower or upper nodes. Those which lie near the ground surface sometimes develop into tillers while those lying at higher levels especially in the axils of the larger leaves form the *"pistillate branches"* bearing the *"cob'* (female inflorescence). The cobs on tillers are of an inferior quality than on the main stalk. This modified branch is called *"shank"*.

Anatomy of the Stem :

Basically the anatomy of wheat and maize stems is similar except that in the latter there is a well developed pith. The cross section of maize stalk thus is made up of four main parts:

1. *Epidermis*: A thin transparent tissue covering the outer part of the stalk and is impervious to moisture.

2. *Hypoderm*: This forms the stem wall just below the epidermis. It is a hard woody layer with sclerenchymatous cells. A few chlorophyllous cells are also found embedded in the hypoderm.

3. *Vascular Bundles*: The stiffness of the hypoderm is also largely attained by the presence of a large number of fibrovascular bundles scattered and closely packed within the hypoderm. These bundles are stiffened by silica deposits and make the stem wall the "back bone" of the plant. The bundles are diffused in the pith in a regular ring.

4. *Ground Tissue*: This consists of parenchymatous cells extending from the hypodermis to the centre. The cen-

tral cavity of the stalk is filled with pith which is a soft, spongy mass of tissues that serves as a storehouse for moisture and food. The large masses of pith separate the vascular bundles in it.

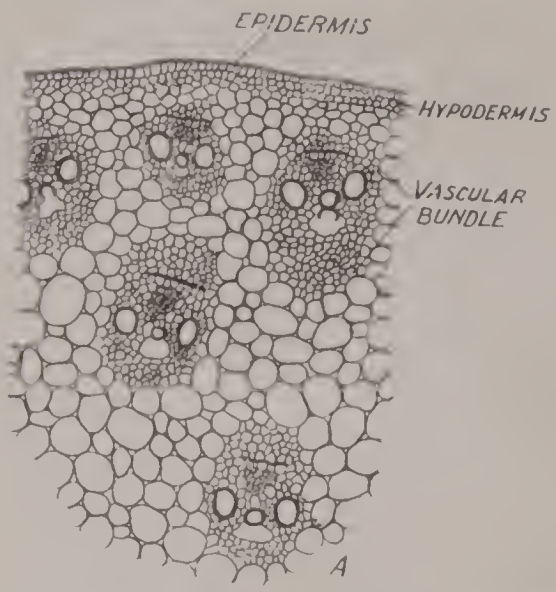

Fig. 8—**TRANSVERSE SECTION OF THE MAIZE STEM (A PORTION)**

Leaf: The leaves of maize consist of—blade, sheath, ligule and auricles. The leaves are simple, cauline, sessile, exstipulate, alternate with phyllotaxy ($\frac{1}{2}$) distichous. Blade: long, broad, flattened, with sheathing base, linear ribbon-like; margin entire and wavy: apex acute; upper surface slightly ribbed, scabrid, hairy; lower surface smooth; venation parallel, multicostate, veins anastomosing towards the base and apex, midrib prominent and yellowish. Sheath: in continuation with the lower end of the leaf blade and attached to the node; closely envelopes the internode lying above upto a variable distance; entire below and free above; surface glabrous or pubescent; margins glabrous below but often becoming strongly fringed with hairs above. Ligule: a membranous structure situated at the junction of the blade and the sheath forms the *'rain guard'*. Auricles: two lateral membranous outgrowths from the edges of the leaf base clasping the stem; sometimes poorly developed or may be absent.

The first formed leaf of each 'pistillate branch' is much modified and known as *prophyllum*. It is a sheath-like structure with two prominent keels.

Anatomy of the Leaf :

Maize leaves are isobilateral and possess more or less similar tissues as in wheat leaves:

1. *Epidermis*: Elongated continuous cells with sinuous margins, present on both surfaces of the leaf and intercalated by stomata. Stomata are more on the lower surface. Each stoma possesses a stomatal cavity beneath. Motor cells and hairs are present only on the upper surface, the former being at regular intervals and in parallel rows.

2. *Parenchyma*: Large, irregular-shaped mesophyll cells ladened with chlorophyll and capable of carrying out carbon assimilation.

3. *Fibro-Vascular Bundles*: With xylem, phloem, sclerenchyma and other tissues similar to that as described in wheat.

Inflorescence: Monoecious but diclinous (stamens and pistils borne on separate inflorescences).

(*a*) *Male Inflorescence*: A terminal panicle called *'tassel'* terminated by the main axis of the plant. This is a compound racemose inflorescence, branching especially from the lower end of the tassel and with compound spikes. The terminal spike is long and thick with a number of spikelet rows (4—7) while the lateral spikes possess two rows of spikelets placed on a straight rachis. The tassel may be erect or drooping.

Male Spikelets: The male spikelets occur in pairs, one sessile and the other pedicelled, attached to a straight rachis. Each spikelet bears two florets or flowers, one upper and the other lower, borne on a much shortened rachilla, both are staminate and identical but the upper one matures first. The florets are finally enclosed in a pair of empty glumes, situated at the base one above the other. In the early stage, the latter overlaps the former and hence is called outer or lower glume (Glume I) while the other is the inner or upper glume (Glume II). Both are almost equal in size, acute in shape,

hairy at margins and apex, but the surface is glabrous, distinctly nerved, rough and empty. Glume I encloses the upper flower while Glume II, the lower flower.

Male Flower: Unisexual—staminate, incomplete and bracteate. The lemma and palea are respectively the outer and inner bracts of the flower. Lemma: more or less oval, 3-nerved and glabrous, apex hairy and slightly rounded. Palea: situated opposite to lemma, thin, membranous, 2-nerved, almost flat and with inturned margins. In the upper flower the palea is larger than the lemma while in the lower flower the lemma is larger than the palea.

Perianth: Represented by two small, fleshy, cup-shaped bodies known as *lodicules* which are inserted opposite the lemma and alternate with the stamens.

Androecium: Stamens 3, free; anthers bilobed, linear, elongated, versatile; filaments short when young and elongate rapidly during flowering.

Gynoecium: Rudimentary.

(*b*) *Female Inflorescence*: This is commonly known as *'ear'* or *'cob'*. It is a modified lateral branch developed from a lower nodal bud borne on the axil of a larger foliage leaf. It is technically termed as *"spadix"* which is a compound racemose with spikes borne on a fleshy axis and enclosed in spathes. The ear consists of a central axis or *'shank'* with nodes and internodes. The length of the internode decreases progressively upwards till that ends into the thick and fleshy cob, arranged therein are a series of paired female spikelets in longitudinal rows, each developing into a single grain. The leaf present at the basal node of the shank is called *'prophyllum'* and the other leaves developing from upper nodes constitute the *'husk'*; the whole forms the *spathe*.

Female Spikelets: The female spikelets are in pairs and densely crowded in several vertical rows on the fleshy rachis. Both the spikelets are sessile and identical, each enclosing two dissimilar flowers or florets, one above the other borne on a very short rachilla. The lower floret is abortive or infertile reduced to two bracts—lemma and palea, with minute scaly lodicules (sometimes) and traces of missing pistil and stamens. The upper flower is fertile, unisexual-pistillate, bracteate and

later develops into the maize grain. Both the flowers are enclosed within two empty outer glumes which are shorter than the ovary, equal in size, broad and fleshy at the base, thin and membranous above and fringed on the edges.

Female Flower: Unisexual-pistillate, incomplete and bracteate. The bracts are in the forms of lemma and palea. Lemma: white, hyaline, short and broad. Palea: hyaline, bifid, more or less in equal size with the lemma.

Perianth: Sometimes present as minute scales in the lower floret only but absent in the upper floret.

Androecium: Present as 3 rudimentary stamens.

Gynoecium: Present as a trace in the lower floret (neutral) and well developed in the upper floret (pistillate). Monocarpellary; ovary superior, ovoid, unilocular, with a single, modified campylotropous, basal ovule; style 1, very long, 3-sided, silky thread-like with unqually divided bifid hairy stigmatic lobes at its apex; stigma very long, protruded and feathery. The silk-like styles fall down in a tuft from the top of the spadix. It is still a controversial question whether the silk-like structure is the style or a compound stigma.

Floral Formulae: $\dagger\ \varnothing\ Gl_2\ Lm_1\ Pl_1\ P_{lod_2}\ A_3\ G_0$

$\dagger\ \varnothing\ Gl_2\ Lm_1\ Pl_1\ P_{lod_2}\ A_0\ \underline{G_1}$

Or $\dagger\ \varnothing\ Br_2\ Brl_2\ P_2\ A_3\ G_0$;

$\dagger\ \varnothing\ Br_2\ Brl_2\ P_2\ A_0\ \underline{G_1}$

Pollination: Cross-pollination is the rule attained by anemophily. Wind and gravity are the chief distributing agents for the pollen grains which are very light in weight and produced in enormous quantities by the tassel. Self-pollination is prevented by dicliny, protandrous or protogynous conditions of flowers.

Fruit: A caryopsis; albuminous, with distinct scutellum.

Germination: Hypogeal.

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Genus: **Avena**

The genus Avena belongs to the tribe Aveneae that includes many important grasses of the tropical and temperate regions. It includes nearly 70 species which are characterized by the paniculate inflorescence, bearing two to many flowered spikelets; involucral glumes exceed the flowering glumes in size, equal, membranous, several-nerved, long and acuminate; floral glumes hard except towards the apex, nerved, apex divided and bearing a twisted awn upon the dorsal side which is straight and reduced in *A. sativa*.

Avena includes many cultivated species of which *A. sativa* (derived from *A. fatua*) and *A. byzantina* (derived from *A. sterilis*) are most widely cultivated both as a cereal and fodder.

Avena sativa Linn.

Hindi: JAVI *English*: Oats

In those parts of the world where rice does not thrive and wheat is not at its best, the farmer often resorts to oats. It is of the greatest relative importance in cold damp countries. In its climatic requirements it can stand almost as much heat as wheat but being nearly always spring sown it has a later growing season. It does require more rain and its moisture requirement practically bars it from the Mediterranean climate with their hot day summers though according to the Russian investigator, Malzew, the primary centre of cultivated oats is probably the western Mediterranean region, but there is much difference of opinion about it and many are of opinion that it is a native to eastern European Russia. The soil requirement of the plant is not unlike that of wheat. It forms a staple food of a large population of the world but it is primarily used as fodder in the Western countries. It has now become a crop of some importance in several parts of Northern India, as a

fodder crop. It grows in the maximum quantity in U. P., Bihar, Orissa and Punjab, in order of importance. Out of these the eastern states alone are responsible for the production of 80% of the total output of India.

The common oats, *A. sativa* is now considered to have been derived probably from *A. fatua* and occurs in two chief forms, the common oats with open spreading panicles and the Tartarian oat with contracted one-seeded panicles.

BOTANICAL DESCRIPTION

Habit: A cultivated annual herb, grown in cold climate.

Root: Both seminal roots and adventitious roots are present. Seminal roots are the first to form, followed by the production of innumerable adventitious roots arising in a whorl from the underground stem nodes. Tillers also develop similar adventitious roots with no seminal roots and finally the root system appears to be a dense fibrous mass.

Stem: Erect, herbaceous, cylindrical, glabrous or hairy with distinct nodes and internodes; the nodes are solid and thicker while the internodes are fistular; lower internodes are shorter than the upper and the inflorescence bearing internode is the longest with a tendency for branching. The oat stem is generally thicker and softer than that of wheat. Tillering occurs in oats but the tillers are fewer in number than in wheat. The habit of the tillers may be erect, semi-prostrate or prostrate. The lodging of the oat, caused by environmental conditions (which play the decisive role) and by weak-stemmed varieties, is a common phenomenon resulting in a considerable loss in yield.

Leaf: Drooping or erect, simple, cauline, exstipulate, ligulate, in two alternating rows, phyllotaxy $\frac{1}{2}$. The leaf consists of lamina or blade, sheath and ligule. *Lamina*: linear, apex acute, entire margin, narrow, rough, hairy on the lower surface and on the margin, with multicostate parallel venation. *Sheath*: closely envelops the axis, but united at the base, glabrous or pubescent. *Ligule*: well developed (absent in some varieties) membranous, oval in shape and ends in a number of fine teeth. *Auricles*: absent.

Inflorescence: A panicle of spikelets. This consists of a main axis or rachis with lateral branches arranged alternately in racemose at each node (generally 5-6 in number) or it may

be unilateral. The lateral branches terminate in a spikelet and other spikelets are arranged in cymose.

Spikelet: This is the unit of inflorescence consisting of generally 3 florets (or flowers) but may vary from 1 to 7. The florets are sessile and arranged alternately on a short rachilla with an upper staminate or imperfect floret and two lateral perfect florets. The two lower florets mature into grains while the upper one remains sterile. The whole spikelet is enclosed in two glumes (Glumes I and II), which are called empty glumes. These are generally equal or subequal in length; thin, membranous, lanceolate, acuminate, glabrous, very long, more or less boat shaped and veined. Glume I practically enfolds Glume II and this envelope forms a complete protection to the enclosed florets.

Flower (floret): Incomplete, bisexual, zygomorphic on account of the position of lodicules, hypogynous, bracteate, flower arising in the axil of the lemma opposite which lies the palea.

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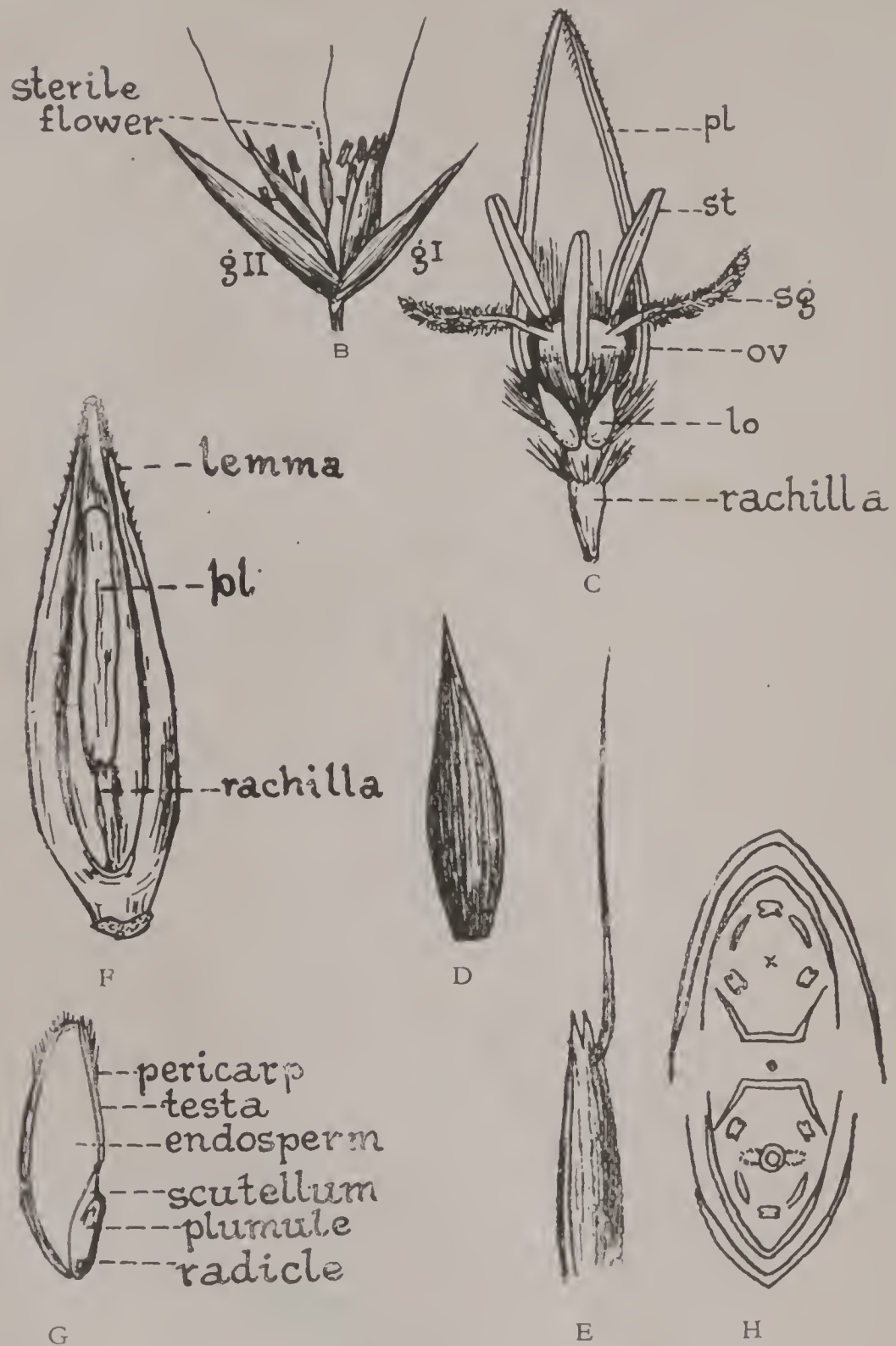

Fig. 9—**OATS**

A. The panicle of oats with a leaf. **B.** Spikelet in flower; gI, first empty glume; gII, second empty glume. **C.** Longitudinal section of a spikelet showing a single floret; pl, palea; lo, lodicules; st, stamen; ov, ovary; sg, stigma. **D.** Glume. **E.** Lemma with awn. **F.** Mature grain of oats (grain situated at the centre). **G.** Longitudinal section of the grain. **H.** Spikelet diagram of oats showing the staminate and perfect florets.

Lemma: ovate lanceolate. broadly convex, membranous or coriaceous, veined, glabrous or hairy—hairs present on the back and towards the base, apex bidentate or extended into two awn-like projections; the base is slightly swollen and hard, known as *"callus"* which may carry hairs or bristles; the shape of the callus varies widely and is well marked in mature grains. The awn is the extension of the midrib of lemma and is generally present on the lower grain only; awns are of various kinds but small, curved or straight and untwisted in the cultivated species. These probably serve as an organ of transpiration and also help in the seed dispersal and burying of grain under natural conditions. Palea: thin, membranous, large boat-shaped, 2-ribbed, little shorter than lemma and closely invested by it, bidentate, glabrous or hairy.

Perianth: Lodicules 2, minute, white membranous in structure; borne on the short axis above the palea.

Androecium: Stamens 3, odd stamen interior; anthers versatile, linear, bicelled, polyandrous, dehiscence introrse; filaments short when young but long and protruding at flowering.

Gynoecium: Monocarpellary; ovary superior, unilocular; style short, single; stigmas 2, lateral, feathery; ovule single, basal, anatropous.

Floral Formula: $\dagger\,\mathfrak{P}\ Gl_2\ Lm_1\ Pl_1\ P_{lod2}\ A_3\ \underline{G_1}$.

Or $\dagger\,\mathfrak{P}\ Br_2\ Brl_2\ P_2\ A_3\ \underline{G_1}$

Pollination: Pollens are shed before and during the flower opening and hence self pollination is easily attained prior to the protrusion of anthers. But as in most cases the flowers definitely open, natural cross pollination by anemophily may occur to a limited extent.

Fruit: A caryopsis.

Seed: Albuminous.

Germination: Hypogeal.

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Genus: **Sorghum**

The genus Sorghum belongs to the tribe Andropogoneae with nearly 13 species which are mainly found in the tropical and subtropical regions.

The genus is characterized by the tall, robust grasslike habit with fewer tillers; typical panicle inflorescence with verticillate or scattered branches; spikelets arranged in pairs, consisting of a sessile and a pedicelled one at each joint of the rachis, are characteristically dissimilar; each bearing 2-florets, out of which one is always sterile but the other is hermaphrodite in the sessile, which later develops into a grain, and staminate or neuter in the pedicelled one.

Sorghum vulgare Pers.

(*Andropogon Sorghum* Linn.)

Hindi: JOWAR *English*: Grain sorghum

The use of Jowar in the Far East is older than history and it is to-day the staple food of millions in the comparatively arid areas of the tropical and subtropical regions far from suitable for rice or wheat. The average temperature during the growing season ranges from 80°–90°F, but many varieties can stand 60°F as a lower limit and about 105°F as maximum. It is a crop of low or moderate rainfall and limited to tracts with

about 40″ as maximum. Below an annual rainfall of 17″ to 18″ it cannot be grown as a dry crop and will have to be raised under irrigation. In India it is the most widely grown dryland food grain largely associated with the black cotton soil, though its yield is not at all poor in the areas of red soil or alluvial soil of the Indo-Gangetic plain. It is the staple food of millions in South India but in the order of importance, mention can be made of Bombay, Hyderabad and M.P.

BOTANICAL DESCRIPTION

Habit: Annual, tall, usually very robust, cultivated grass.

Root: Primarily adventitious, branched and fibrous but seminal roots are produced at the beginning, which according to some, decay off with the development of the secondary (adventious) roots. The root system is widely distributed due to profuse branching but is limited to the upper horizon of the soil. After the harvest of the crop, the roots and the stubbles decay, producing some injurious substances which badly affect the ensuing crop.

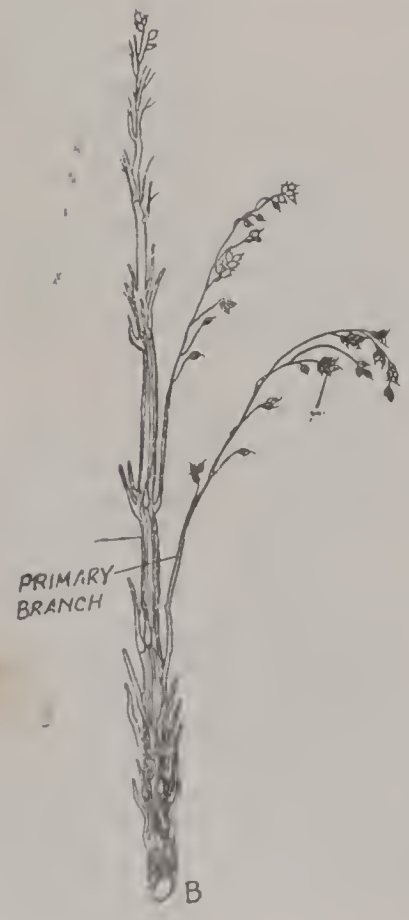
Stem: Erect, aerial, solid, slightly furrowed, cylindrical, herbaceous, having prominent nodes and internodes, nodes swollen, internodes glabrous, showing a whitish substance near the node, semicovered with leaf sheath, the length of the internodes goes on increasing towards the apex and the terminal node ends into the *'head'*. Buds are found on each node except the terminal one, and those lying on the ground level may develop into tillers. Lateral branches sometimes occur bearing heads under favourable conditions; the maturity of the heads takes place from the apex downwards.

Leaf: The foliage leaf consists of blade or lamina, sheath, ligule and auricle. Leaves simple, cauline, sessile, exstipulate, large, herbaceous; convolute in bud; phyllotaxy alternate ($\frac{1}{2}$). Blade: long, broad, flattened, with sheathing base, linear, margin entire, slightly wavy; apex acute; upper surface rough and hairy, lower surface smooth; parallel multicostate venation, with prominent midrib. The leaf blades are very similar to those of maize except that they are more erect and the midrib is better developed. Sheath: long, developing from the node, more or less enveloping and exceeding the length of the internode; entire below and free above; margins membranous and overlapping; practically glabrous, inner face is white and

glistening. Ligule: short, membranous and fringed. Auricles: poorly developed.

Inflorescence: A panicle of spikelets, popularly known as *"head"*. It may be erect or nodding with verticillate or scat-

A



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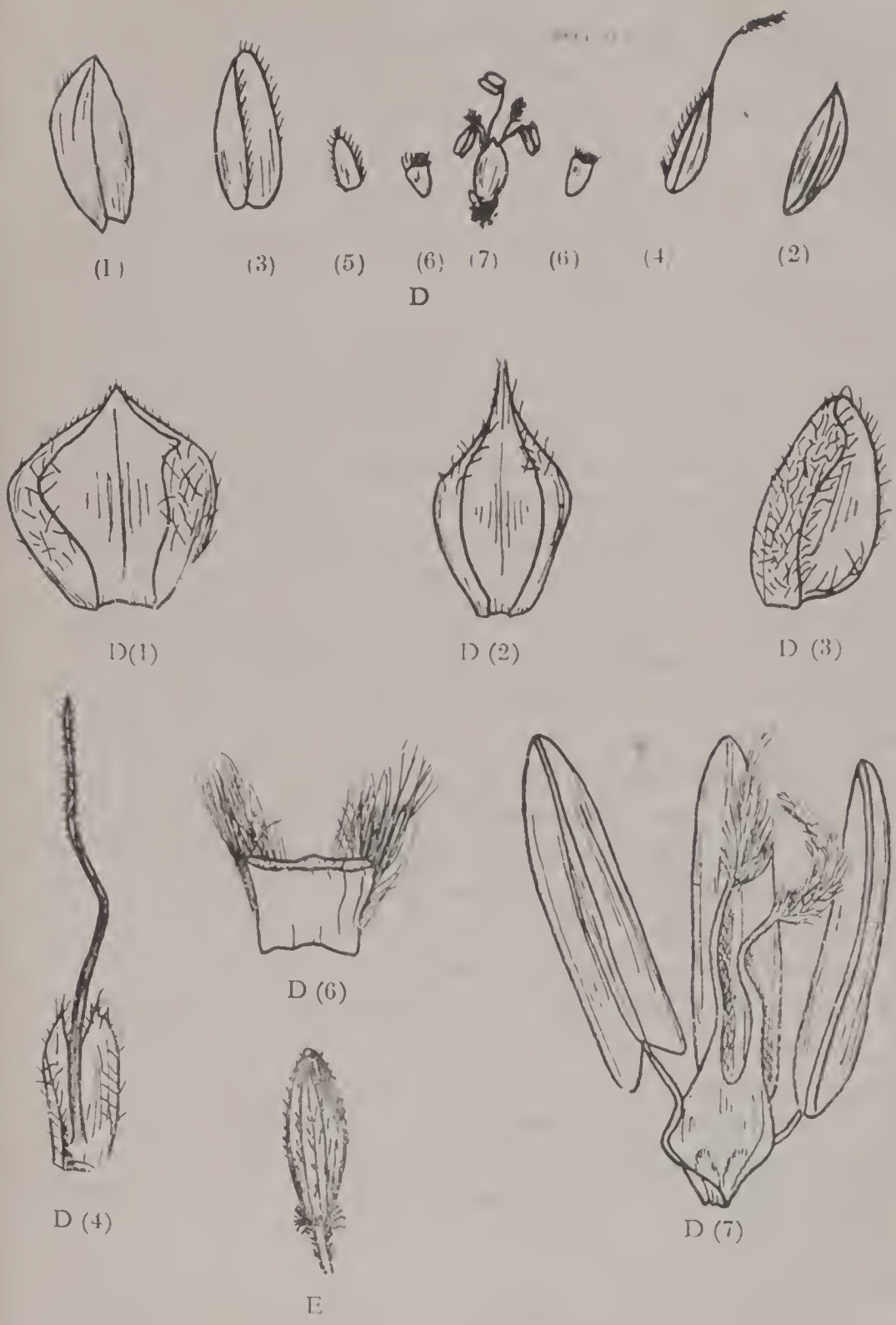

Fig. 10—**GRAIN SORGHUM**

A. Head of sorghum. **B.** The panicle inflorescence of sorghum showing main axis, primary branch and spikelets. **C.** Fertile spikelet with sterile spikelet attached. **D.** A dissected sessile spikelet (fertile)—(1) first glume; (2) second glume; (3) sterile lemma; (4) fertile lemma; (5) palea; (6) lodicules; (7) stamens and pistil attached. **E.** Pedicelled spikelet (sterile).

tered branches; in wild species mostly loose and in the cultivated forms often variously contracted to compact. The lateral branches are again branched and the degree of branching may go up to third order but decreases towards the apex giving the head its usual form of a cone. The main axis varies in length, narrowing towards the apex, angular or furrowed, hairy throughout but more at the nodes (in some varieties the ridges may only be hairy, fringed or covered with fine bristles), jointed, joints when forcibly separated leave a ragged scar at the tip. The lateral branches or rays develop from the node or from any part of the main axis either spirally or in whorls. Lateral branches are somewhat angular, slightly devious, pulvinus based, hairy at the base and at the axils and the ultimate branches may have still finer hairs or glabrous. Spikelets occur in pairs. those of each pair differing in shape and sex, one sessile and perfect, the other pedicelled and staminate or represented by a pedicel only. In the terminal one which is in three, one is sessile and perfect and the other two are pedicelled and staminate; or at times, one staminate and the others perfect. These spikelets are arranged on the articulate fragile or tough rachis (in cultivated forms) of panicled few, jointed racemes, the sessile spikelet falling with the contiguous joint and the accompanying pedicelled spikelet or at least its pedicel.

Sessile Spikelet: This is also called the fertile spikelet and is relatively larger than the pedicelled one. The shape may be ovate, oval, elliptical or obovate. The involucral empty glumes are equal, leathery (rarely chartaceous) with thickened base, prominently nerved, blunt apexed and pubescently hairy. Glume I with a broad flattened or convex back, margins narrowly inflexed near the tips and elsewhere involute, and more conspicuously nerved. Glume II more or less boat-shaped narrow, hyaline, partially enveloped by Glume I and usually with upwards ciliate margins.

Flower (of sessile spikelet): Within the involucral glumes lie two florets, the lower sterile, the upper perfect. The flowers are zygomorphic, incomplete and bracteate, The lower floret possesses only one bract, lemma which is somewhat truncate, empty, hyaline, ciliate, 2-nerved or nerveless and partially enfolds the perfect floret. The upper floret is perfect and develops into grain; the lemma is narrow, oblong to ovate, membranous, 1–3 nerved, two cleft or dentate, with the lobes

free or more or less adnate to a perfect or variously reduced awn or a mucro rising from the sinus, rarely entire and mucronate or muticous. The palea, if present, is small and thin, often minute or absent.

Perianth: This is present in the form of lodicules, two in number, short and broad, truncate and fleshy, ciliate or glabrous.

Androecium: Stamens 3, odd stamens interior; anthers linear; dehiscence longitudinal.

Gynoecium: Monocarpellary; ovary superior; ovule single, single, basal, anatropous; styles 2, long, terminal or subterminal; each ending in a short bushy stigma.

Pedicelled Spikelet: Much narrower than the sessile and more pointed, lanceolate to subulate, male or neuter, sometimes reduced to the glumes or one glume only or quite suppressed. This is borne on a short, angular and ciliate pedicel which is usually fragile, sometimes tough and tenacious. Involucral glumes permanently herbaceous, awnless, coriaceous, enclosing two dissimilar florets.

Flower (of pedicelled spikelet): Enclosed within the empty glumes, one lower and the other upper. The lower floret is represented by lemma only and is sterile. The upper floret is usually staminate; lemma short, 1-2 nerved, ciliate, distinct with awn; palea absent.

Perianth: In the form of 2 lodicules.

Androecium: Stamens 3, odd stamen interior; anthers linear with longitudinal dehiscence.

Gynoecium: Absent.

Normally the fertile spikelet (sessile) bears only a single grain but sometimes a development of more than one grain has also been observed, then the spikelet is called *"abnormal spikelet"*.

Floral Formulae:

Bisexual flower: $\dagger\,\mathfrak{P}\ Br_2\ Brl_{1\text{ or }2}\ P_2\ A_3\ \underline{G_1}$.

Male flower : $+\,\mathfrak{\delta}\ Br_2\ Brl_1\ P_2\ A_3\ G_0$

Pollination: The flowers are protogynous and the anthers usually begin to dehisce as they become pendant by two narrow slits at their apices and at this stage the anthers and stigmas are practically in contact. Thus selfpollination is the rule

although cross-pollination also occurs by anemophily to a limited extent.

Fruit or seed (grain): Caryopsis; white, yellow, red, brown or black in colour with many intermediate shades, obovoid in wild species and globose or subglobose in cultivated ones; dorsally compressed; embryo as long or slightly longer than half the grain.

Germination: Hypogeal.

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Genus: **Pennisetum**

The genus pennisetum includes about 50 species which are mostly found in the warmer regions of the world. *P. typhoideum* is the most important species which is extensively cultivated in India.

The plants are annual or perennial grasses, characterized by the spike-like racemose inflorescence with involucellate clusters, consisting of unequal, scabrid, plumose, simple (or branched) bristles and shortly pedicellate (or sessile) spikelets articulated on a simple rachis. Spikelets 1–3 in each involucel, 1-2 flowered, obovoid or lanceolate, glabrous or sparsely hairy. Lower involucral glume (Glume I) small or absent and upper involucral glume (Glume II) subequal to the lower floral glume (lemma of lower floret), 5–7 nerved, awned or not, rarely absent. Lemma of lower floret (lower floral glume) is paleate or not, male or empty and of upper floret (upper floral glume) sessile, coriaceous, bisexual or female, articulate at the base and deciduous. Palea are small, membranous, delicate, translucent bodies encircling the stamens. Lodicules absent (or 2). Stamens 3; anthers linear. Styles long, free or connate below. Grain oblong, orbicular or pyriform, free within the hardened glume and palea.

Pennisetum typhoideum Rich.
(*P. typhoides* Stapf. and Hubbard)

Hindi: BAJRI, BAJRA *English*: Cat-tail—, bulrush—, or pearl millet

Though claimed by many to be the oldest cereal in man's dietary, the origin and history of *Bajra* is still very imperfectly known. It seems very probable, however, that the plant originated either in India or Africa as it is widely grown in both these places. It is also quite well known in Arabia and Southern Europe. It has very recently been introduced in the United States and is being widely grown as fodder. It is a hard crop that can stand drought, consequently, it covers a wide range of latitude from temperate to the tropics. It thrives best in sandy loams or well drained light soils. It is grown in soils which are too poor for most other cereals.

Bajra is grown in India as *kharif* crop but more usually as a catch crop. The crop is at its best under conditions of a

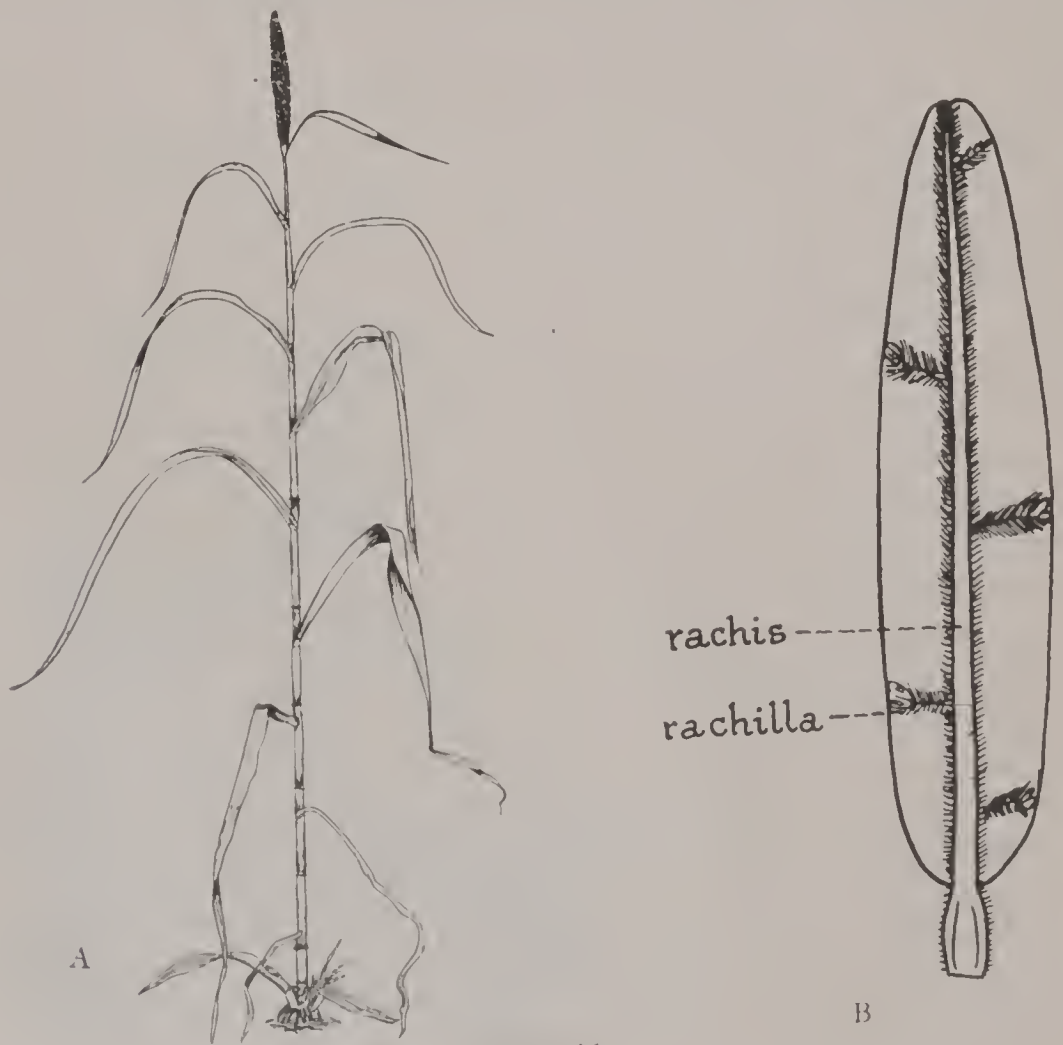
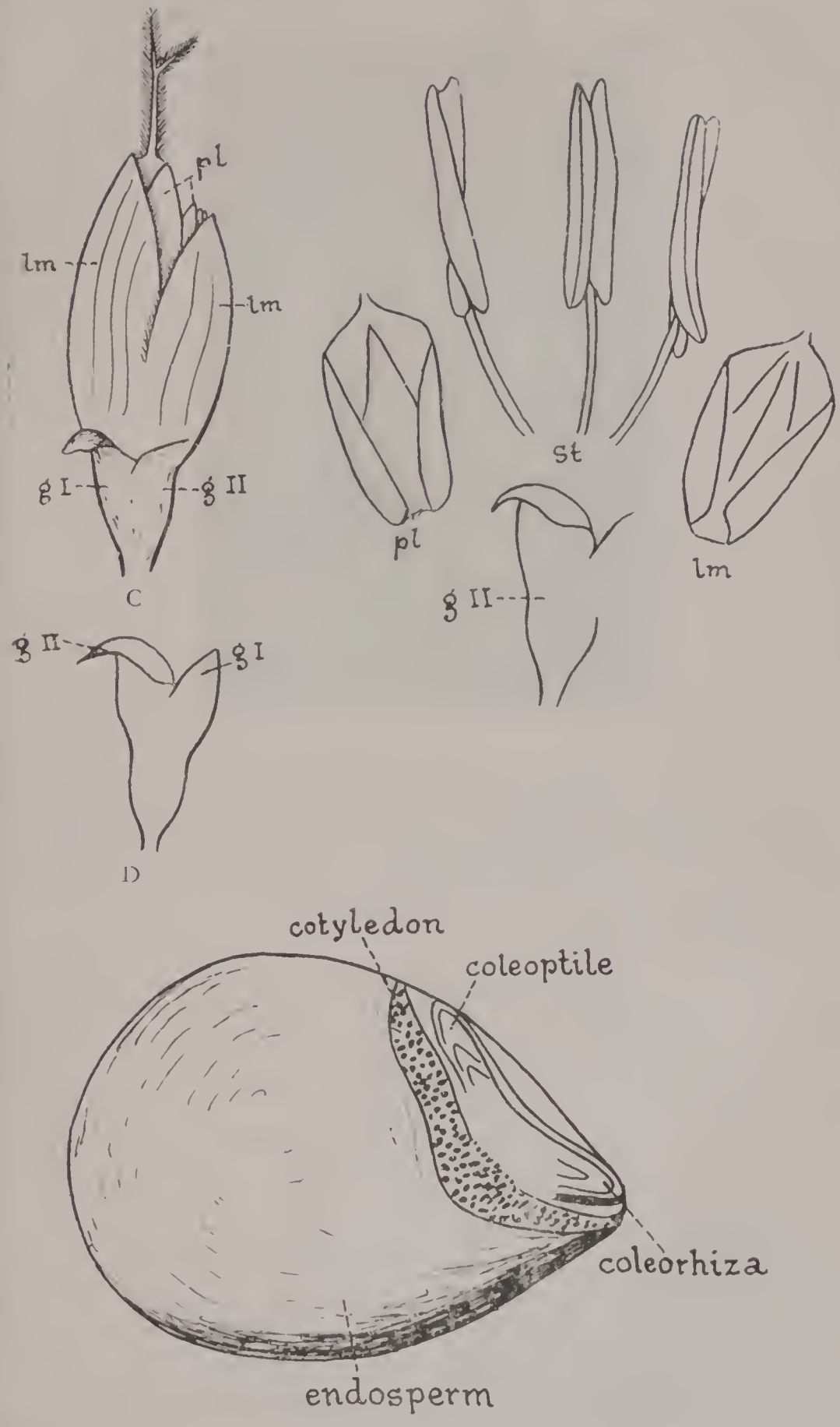


Fig. 11


pl
lm
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C
St
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D
cotyledon
coleoptile
coleorhiza
endosperm
F

Fig. 11 (contd.)

G

Fig. 11—**PEARL MILLET**

A. A pearl millet plant. **B.** Diagram of longitudianl section of the inflorescence showing the rachis with a few rachillae. **C.** A single spikelet. **D.** Glumes; gI. first empty glume; gII, second empty glume. **E.** The lower floret dissected out; lm, lemma. pl, palea; st, stamen. **F.** Longitudinal section of the grain. **G.** A few heads of pearl millet.

light shower followed by bright sunshine during the formative period. In India the crop is grown in most parts of the country except Bengal and Assam. The most important states producing the crop are Madras, Bombay and U. P.

BOTANICAL DESCRIPTION

Habit: A cultivated annual with strong, erect, stout culm carrying a cat-tail ear head at the top.

Root: The root system is typically that of a gramineae. On germination, the coleorhiza breaks through the pericarp and emerges out as the primary root (seminal root) and that gives rise to small, delicate lateral branches throughout its length. The function of the primary root is soon supplemented by the adventitious secondary roots, springing from

the subterranean stem nodes usually in a whorl of 4–6 roots. At the base of the stem, near the ground, where internodes are longer, a few series of roots function as prop roots which assist in keeping up the plant erect. Each tiller develops its own independent secondary root system similar to that of the main stem and thus ultimately it appears to be a thick mass of fibrous adventitious roots at the bottom of the culm.

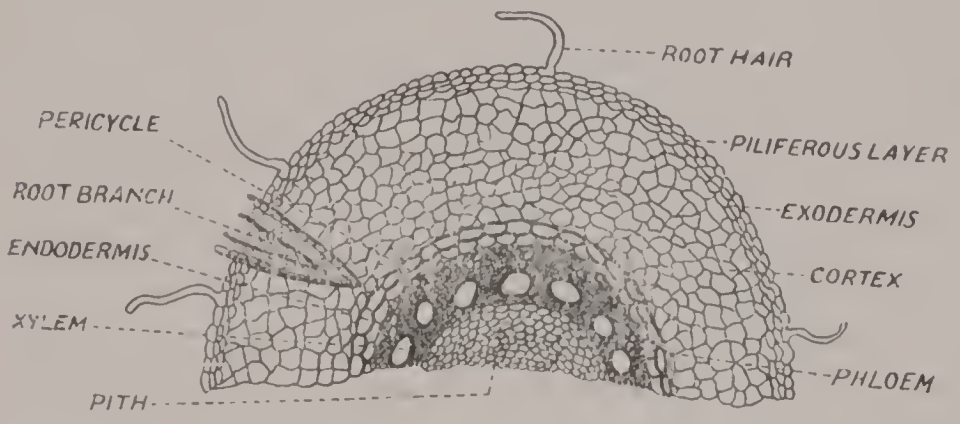

Fig. 12—**ANATOMY OF PEARL MILLET PLANT**

Transverse section of the root (a portion).

Anatomy of Roots: A thin transverse section through a well developed root of Pennisetum shows the following tissues:

1. *Piliferous Layer or Epiblema*—is the single outermost layer with a number of unicellular root hairs.

2. *Exodermis*—consisting of 2-3 layers of thick-walled cells beneath the piliferous layer.

3. *Cortex*—a many layered zone of thin parenchymatous cells. The outer layers of cortex are cutinized and form exodermis.

4. *Endodermis*—forms a ring around the stele and consists of a single layer of cells with thick inner walls.

5. *Pericycle*—a single layer of cells lying ring-like on the internal side of the endodermis.

6. *Vascular Bundles*—consisting of the xylem and phloem groups arranged alternately in radial ring and lined from within by a band of sclerenchymatous fibres. Bundles are numerous.

7. *Pith*—is the central portion of the stele consisting of moderately thick-walled parenchymatous cells and is well developed here.

Stem (or culm): Tall, aerial, erect, cylindrical, solid, having a prominent longitudinal groove furrowed on the side next the leaf blade; glabrous, but sometimes woolly pubescent below the inflorescence; nodes and internodes distinct; the length of the internodes increases from the base to the apex and is surrounded by leaf sheath; nodes surrounded by a ring of long white cilia pointing upwards, the quantity of which increases towards the apex of the stem. Buds develop at the nodes on the axils of the leaf which usually remain dormant and those on the ground level may develop as tillers; each of which produces a terminal head, although tillering is limited.

Anatomy of Stem: A transverse section through the stem presents the folllowing structures:

1. *Epidermis*—a single outermost layer with a thick cuticle on the outer surface.

2. *Cortex*—consisting of 1-2 layers having more or less thickened cell walls forming a narrow zone of hypodermis lying below the epidermis.

3. *Ground Tissue*—made of thin-walled parenchyma extending from the cortex to the centre of the stem.

4. *Vascular Bundles*—collateral and closed, numerous in number, scattered and present at the peripheral region of the stem and more broad and closely distributed near the periphery. They contain air spaces on the innerside of the xylem portion and are surrounded by sheaths of sclerenchyma.

Leaf: Alternate, phyllotaxy $\frac{1}{2}$: auriculate and ligulate, auricles prominent while the ligule is an undeveloped small white structure having long and densely ciliate rim. The leaf proper consists of sheath and lamina. *Sheath*: somewhat thicker than the lamina, slightly longer or shorter than the internode and encircling the culm with open top but overlapping at the base, the inner portion is whitish and transparent while the outer surface is usually glabrous (sometimes hairy) and faintly grooved. Occasionally the basal ones possess a reddish outer surface where the collor is distinct, purple in colour with a fringe of whitish projecting cilia at the base of the pigmented area. *Lamina*: linear to linearlanceolate with a round base; margin slightly wavy, entire; the upper surface is rough and grooved due to the prominent midrib which prevents the blade from drooping while the lower surface is smooth; hairy or glabrous, parallel veined; in

majority of the cases the basal portion of the lamina possesses hairs along the upper margins (may be absent). Stomata present on both surfaces.

Anatomy of the Leaf: The leaves of pearl millet are of isobilateral type and hence show uniform structures on both sides:

1. *Epidermis*—present on the upper and lower surfaces of the leaf and consists of rectangular cells arranged in parallel rows along the long axis. This contains stomata and unicellular hairs.

2. *Mesophyll Cells*—exist between the epidermal layers and spongy in character with chloroplast pigments.

3. *Vascular Bundles*—lie parallel to the midrib of the leaf blade and spaced at regular intervals, there is a series of veins each having a single vascular bundle which is similar to that of the stem. The vascular bundles consist of—(a) Sclerenchyma–sheathing the phloem and xylem from both the sides, (b) Xylem—situated towards the upper surface, and (c) Phloem—situated towards the lower surface. The size of the vascular bundles varies and those possessing larger veins are slightly raised on the upper surface.

4. *Motor Cells*—Situated between two veins of the upper epidermis in longitudinal groups and are hygroscopic, containing water under normal conditions. When transpiration is excessive, these cells loose their water content and cause the upper surface to shrink and curve inwards, tending to check the water loss.

Inflorescence: A terminal dense cylindrical compound spike-like panicle, where the *'rachillae'* are spirally arranged round the central axis called *'rachis'*. The rachis or the axis of inflorescence is a straight, solid, fleshy, cylindrical structure, as long as the length of the earhead and tapers gradually towards its apex and possesses a thick coating of soft short hairs all over its body. On this rachis are arranged spirally the small structures of villous rachillae (secondary axes of inflorescence) each carrying a group of spikelets usually two in number. Each spikelet consists of a sterile and a fertile flower, subtended by an involucre of scabrid plumose bristles about as long as the spikelets, slightly curved in shape. In awned varieties some of the inner bristles elongate 3–5 times their usual length and form *'awns'*. The bristles or awns in

some cases have a pinkish colour varying widely in intensity. The whole inflorescence appears somewhat like the cat's tail and hence often named as *"cat-tail millet"*. The thickness of the spike or head depends on the length of rachillae and its inclination to the rachis as well as on the length of the spikelets.

Spikelet is really the unit of inflorescence and is sessile or shortly pedicelled, usually ovate or oblong in form, situated within the involucre of bristles, readily deciduous when ripe and consists of two empty glumes (Glumes I and II) and two florets (lower—staminate or neuter, infertile and upper—hermaphrodite, fertile) with two bracteoles in each (lemma and palea). The empty glumes are quite rudimentary; Glume I (first empty glume) short, broad, membranous, truncate, half—spherical, upper margins somewhat fimbriate; Glume II (second empty glume)—half the length of the spikelet, slightly larger than the breadth, subquardate, truncate, terminating in a round end, 5—7 nerved, slightly coriaceous, somewhat two-cleft with margins fimbriate, awned or awnless.

Flower (floret): Two in each spikelet; incomplete; zygomorphic; unisexual, bisexual or neuter; lower floret—sterile, staminate or neuter (rarely perfect); upper floret—fertile, hermaphrodite and slightly longer than the staminate flower. Lemma: of lower floret—oblong lanceolate, acuminate, 3-nerved, sparsely hairy, smaller than palea; of upper floret—ovate oblong, coriaceous or herbaceous, glabrous, 5—7 nerved with incurved ciliate margin and acute apex. Palea: small, membranous, dorsally 2-nerved, broad, narrowly oval, delicate, thick and translucent, encircling the stamens and ciliate at the tip.

Perianth:—Absent.

Androeciam: Stamens 3, odd one interior; anthers versatile and linear; dehiscing longitudinally; anther cells possess bearded tips.

Gynoecium: Absent in the lower floret but present in the upper one; ovary superior, monocarpellary, one-celled, containing a single ovule, smooth, with two styles which are generally connate at the base and the upper part possesses stigmatic hairs over its surface, each of which is capable of admitting pollen tubes.

There exists a wide variation regarding the nature and number of flowers in spikelets.

Floral Formulae: $\begin{cases} \dagger\ \delta\ Gl_2\ Lm_1\ Pl_1\ P_0\ A_3\ G_0 \\ \dagger\ \varphi\ Gl_2\ Lm_1\ Pl_1\ P_0\ A_3\ \underline{G_1} \end{cases}$

Pollination: The protogynous nature of the flowers suggests the vast extent of cross-pollination that normally takes place in this crop. In the lowermost part of the spike, however, there is a certain overlapping due to the fact that the styles, owing to their late emergence stand some chance of coming across pollen derived from the same inflorescence.

Fruit (grain): The fruit or grain is a caryopsis which at maturity protrudes beyond the lemmas and readily becomes free. The exterior cover of the grain is the pericarp which is usually smooth and shining. The grain is oblong or obovoid in shape, with a trace of style laterally exserted and the colour varies from whitish yellow to dull light blue. The seeds are endospermic and the endosperm fills the whole interior except the small space occupied by embryo. The embryo is fairly obvious, lies on the ventral face and on the base of the dorsal face is an oval brownish scar. The structure of the seed is similar to other cereals with the presence of aleurone layer, starch parenchyma, endosperm and embryo.

Germination: Hypogeal.

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Genus: Saccharum

The genus saccharum comprises of about 37 species and are mostly found in the tropics and subtropics. This includes tall herbs with a characteristic inflorescence which is a large panicle, often silvery, silky and showy, silky hairs arising from the base of the spikelet; spikelets alike in pair—one sessile and the other pedicelled; each bearing 2 florets, the lower reduced to empty valve, and the upper hermaphrodite. Involucral glumes (Glumes I and II) equal, often chartaceous to subcoriaceous towards the base, membranous to subhyaline upwards. Lemma present or absent, hyaline, bristle-like or mucronate. Palea similar to lemma and pubescent. Lodicules 2, wedge-shaped. Stamens 3 in a single whorl. Stigmas feathery and laterally exserted. Grain small, oblong to subglobose; embryo short to half the length of the grain.

Saccharum officinarum Linn.

Hindi: GANNA, IKH *English*: Sugarcane

Sugarcane is a native of India and has been grown as a forage crop for making syrup since ancient times. Tropical in origin, the plant is at home in hot countries and does its best only where free from frost. The best cane sugar crops require such climatic conditions as exist in Cuba, Java and Southern India where there is a temperature of 75° or 80°F all round the year and a rainfall of 60″ or its equivalent by irrigation. Irrigation is of great advantage as there is much necessity of sunshine for the optimum growth of the crop. It requires fertile loamy and alkaline soil. In India sugarcane is grown in the Terai region of the Himalaya and the Indogangetic plain. The states U.P., Punjab and North Bihar are responsible for the production of 80% of the crop and forms the main cash crop of the area and the total production of the country comes to 5 million tons to supply the total requirement of sugar. It is possible to turn all sugarcane by-products into useful substances. The cane tops can be used as cattle feed. The dry trash which contains 40% cellulose can be manufactured into paste-board and wrapping-paper. Bagasse can give charcoal, acetic acid and tar and if used as fuel the ash it leaves can be used as fertilizer. Molasses can be used for producing common alcohol. In short, nothing goes a waste.

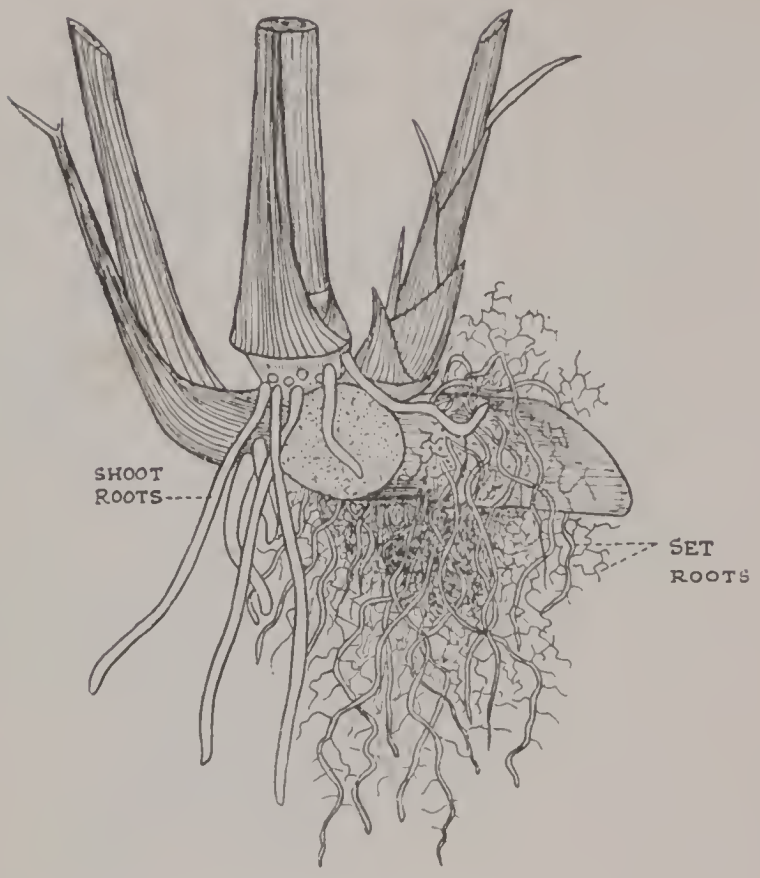
BOTANICAL DESCRIPTION

Habit: It is a stout perennial grass which stools (tillers) prolifically from the base.

Root: On germination of the sugarcane seed, a single seminal root is produced which is later replaced by adventitious fibrous secondary roots. When sets are sown, they develop two kinds of adventitious roots—*"set roots"* and *"shoot roots"*. Set roots originate from the root rings (root primordia) of the cutting and are thin and much branched. Shoot roots develop much after the formation of set roots, developing after the formation of the shoot, springing from the lower root rings of the shoots and are thick, fleshy, white and less branched. The set roots function for sometime and then die, being replaced by the shoot roots; still later the shoot roots, like the set roots, also tend to die off being replaced by newer roots from higher nodes of the same shoot and from the nodes of later formed tillers. The adventitious fibrous roots are continuously renewed by fresh tillers and ultimately give rise to the typical shallow adventitious fibrous root system of a monocotyledon.

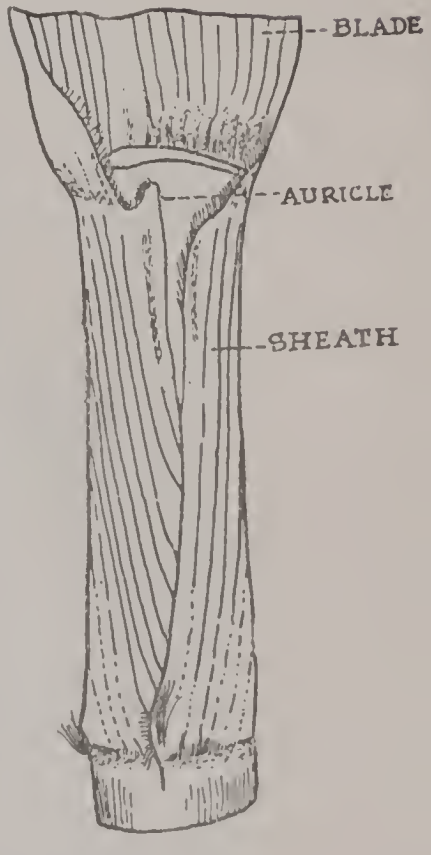
Stem: Solid, hard, with distinct nodes and internodes, the number of which varies with varieties and growing conditions, the length of the internodes increases from below upwards, but towards the apex they again shorten. The nodes contain root band (root ring) with root primordia and an alternately situated axillary bud (sometimes may be more in number or absent) located on the root band. To the upper and lower sides of the root band are situated the *growth ring* and *leaf scar* respectively. The internodes are waxy, with glabrous surface which may, however, develop cracks—small (corky cracks) or deep (growth cracks)—depending on hereditary constitution and environmental conditions. The top most internode extends into the peduncle. Although buds occur in the leaf axil at each node normally only the basal nodes develop into branches or tillers, but if the apical portion of the stem is removed, some of the lower buds lying immediately below the apex develop into branches. The inhibiting effect of the top on the development of the lateral buds is called *'top dominance'*.

Sugarcane is propagated asexually from the stem cuttings (*sets*) each bearing one or few buds and is harvested before



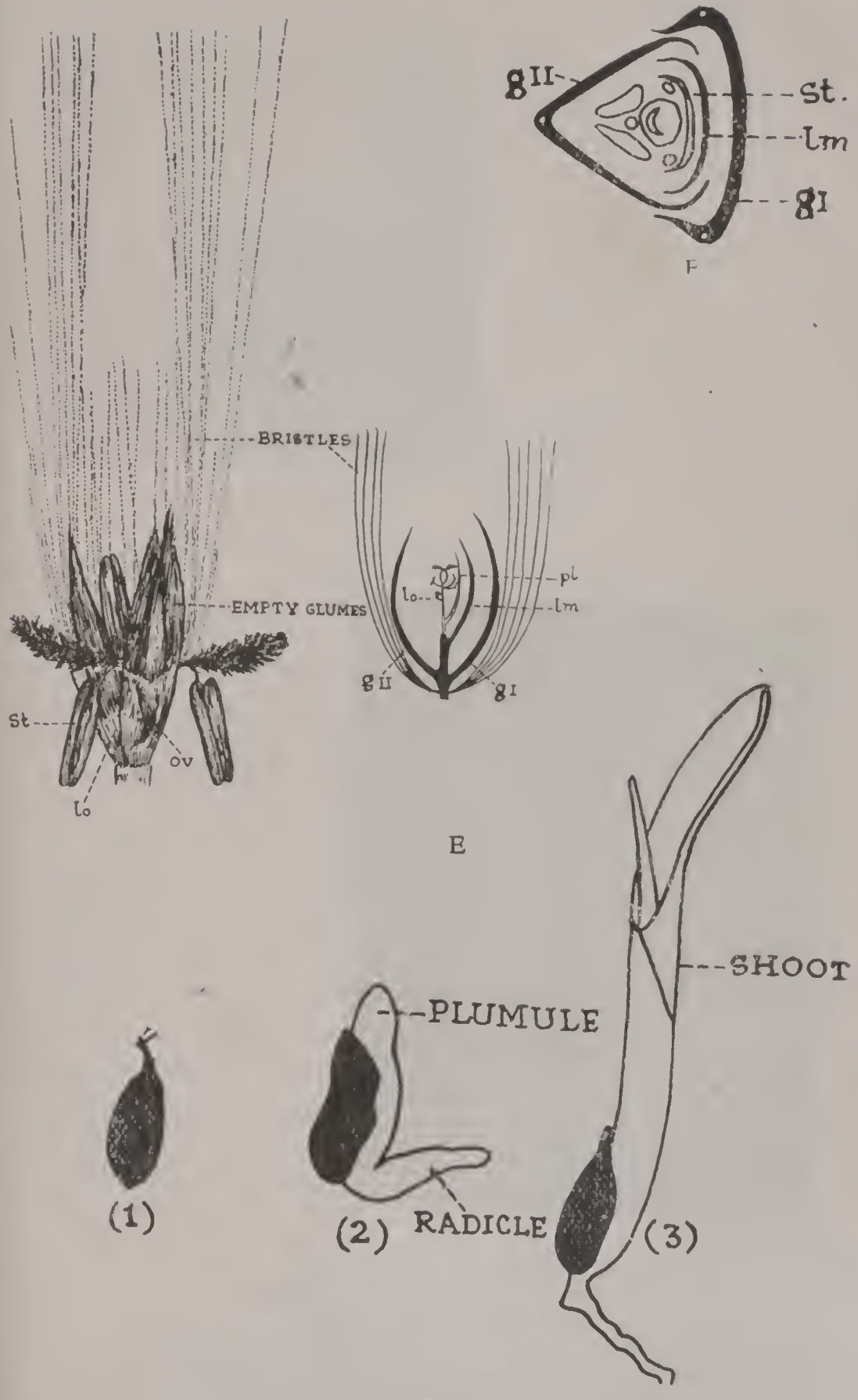
A

B



C

Fig. 13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RADICLE
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G

Fig. 13 (contd.)

H

I

Fig. 13—**SUGARCANE**

A. Roots from a sown set. **B.** Stooling in sugarcane. **C.** A portion of the leaf. **D.** Longitudinal section of a spikelet. **E.** Arrangement of fioral parts. **F.** Floral diagram. **G.** Germination of sugarcane seed. **H.** Sugarcane plant in field. **I.** Sugarcane arrow (inflorescence).

flowering. Sugar is contained in the soft central tissues of the stem and the juice extracted after crushing between rollers. This is later boiled down by the open-pan-system (indeginous) or under reduced pressure (manufacture) and laid out to crystallise.

Leaf: Typically graminaceous, each leaf exhibits the characteristic blade, sheath, ligule and auricles. The leaves are attached alternately to the nodes, thus forming two ranks on opposite sides, which lie in approximately same plane (phyllotaxy $\frac{1}{2}$). Blade: linear, lanceolate, with prominent midrib, projecting from the lower surface and forming a groove on the upper, with two asymmetric halves; margin dentate; surface hispid to pubescent. Sheath: inserted at the node and gradually narrows to its junction with the blade, tubular; margins hairy or glabrous and overlapping. Ligule: fairly well developed, membranous, pubescence restricted to the dorsal surface and free margin. Auricles: ear-shaped, located at the upper part of sheath margin, number may vary from 0 to 2.

Inflorescence: An open branched loose terminal panicle, the degree of branching may go up to second or third order, the branching is more profuse towards the base, the lateral axes are implanted on cushioned joints. Spikelet is subtended at the base by a ring of long hairs, which give a silky appearance to the whole inflorescence and contains two flowers, the lower sterile and the upper hermaphrodite and fertile. Glume I—lanceolate, bicarinate, apex hairy. Glume II—similar as Glume I but with distinct midrib and longer hairs along the margin.

Flower (floret): Fertile (upper floret of the spike) or infertile (lower floret), incomplete, zygomorphic. *Lemma*: May or may not be present with the fertile flower, narrow nonvascular, tipped with fine hairs. *Palea*: Small, differs in shape and pubescence and strongly invested by lemma of the sterile flower.

Perianth: As 2 lodicules, wedge-shaped and strongly ciliated in certain forms.

Androecium: Stamens 3, in a single whorl, one inserted between lodicules and the other two on the opposite sides; filaments white and round, elongating and protruding rapidly during anthesis; anthers bilobed, versatile.

Gynoecium: Carpel 1; ovary superior, obovate to obconical, round but somewhat flattened on the ventral side with a single anatropous ovule; styles 2, terminal, each ending in a feathery stigma.

Floral Formula (fertile flower):

$$\dagger\ \mathbb{Q}\ Gl_2\ Lm_{1\text{ or }0}\ Pl_1\ P_{lod_2}\ A_3\ \underline{G_1}$$

$$\text{or}\ \dagger\ \mathbb{Q}\ Br_0\ Brl_{1\text{ or }2}\ P_2\ A_3\ \underline{G_1}$$

Pollination: Cross-pollinated by anemophily.

Fruit or Seed: A caryopsis, extremely small and a longitudinal section shows the integuments, aleurone layer, endosperm and embryo. The embryo possesses a plumule and radicle which are connected by a mesocotyl. The embryo and endosperm are separated by the scutellum.

Germination: Hypogeal. The seed has poor keeping quality and is often inviable when produced under improper photoperiodic and environmental conditions.

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Genus: **Eleusine**

The genus Eleusine includes 10 species, widely distributed in the tropical and subtropical regions of the world, many of them cultivated for food and fodder. These are annual or perennial herbaceous grasses, with typical inflorescence of spikes in interrupted spikes, either the upper or all in a terminal umbel, straight, sub-erect, spreading or deflexed; spikelets glabrous with 3—6 flowers, laterally compressed, densely imbricate, alternately two-whorled, unilateral, sessile on a flattened rachis, the uppermost terminal is imperfect and the remaining flowers are fertile and bear grains.

Eleusine coracana (Finger millet) is the most important species of the genus grown widely in India and Africa which is probably derived from the ruderal grass (*E. indica*).

Eleusine coracana Gaertn.

Hindi: RAGI *English*: Finger millet

Ragi is one of the hardiest crops which can withstand drought. It grows as a dry crop in the areas where rainfall ranges from 20″—35″. It is grown mainly on the red soil but also favours loams and sandy loams and it avoids rough and gravelly soil. It can also grow on somewhat clayey soils the same kind as are favourable for rice and therefore forms part of the rotation with it. It is a great nutritive grain considered as the chief source of sustenance to people doing hard labour.

The dry areas that lie in the rain shadow of the state of Mysore with fertile red soil is noted for the good production of Ragi.

Fig. 14—**FINGER MILLET**

A. A finger millet plant showing the newly developing ear and leaves. **B.** The inflorescence (ear). **C.** A portion of the inflorescence. **D.** A single spikelet.

BOTANICAL DESCRIPTION

Habit: An annual cultivated grass grown for grain and forage as a *kharif* crop in India. The plants are dwarfish in habit and tiller profusely.

Root: Chiefly adventitious fibrous. The roots are neither much branched nor can be called as deep or wide spreading. But these are numerous in number, permeate and hold the soil firmly and are very efficient absorbants of moisture; hence they are able to thrive through acute droughts and revive surprisingly after a shower of rain.

Stem: Erect or slightly kneed, compressed and glabrous. It is grouped under such grasses which have flattened stems and round nodes.

Leaf: Numerous, linear, acute apexed, glabrous with ciliated margins, flaccid, folded, distichous, often far overtopping the stem with sheathing base. Sheath compressed, loose or open, striate, glabrous and with ciliated margins. Ligules short, membranous and fimbriate.

Inflorescence: Borne at the end of the culms as earheads which consist of finger-like spikes, 2—7 in number on a terminal umbel, straight, suberect, spreading; rachis slender, 2″—4″ in length, often pubescent at the base and the spikelets are arranged closely on both sides of the rachis. Spikelet often curved with 3—6 flowers, much congested and awnless. Involucral glumes (Glumes I and II) subequal, persistent, obtuse or obscurely mucronate, membranous, strongly keeled, 3—5 nerved.

Flower (floret): Perfect or imperfect (only the terminal one which is staminate or infertile), trimerous, incomplete, zygomorphic. *Lemma*: broadly ovate, acute and three-nerved. *Palea*: similar as lemma but shorter with two winged keels.

Perianth: Lodicules 2, minute, broad and truncate.

Androecium: Stamens 3.

Gynoecium: Monocarpellary; ovary glabrous, obovate, superior with an anatropous ovule; style slender from a broadened base; stigmas feathery and laterally exserted.

Floral formula: † ☿ Gl_2 Lm_1 Pl_1 P_{Lod2} A_3 $\underline{G_1}$.

or † ☿ Br_2 Brl_2 P_2 A_3 $\underline{G_1}$

Pollination: Invariably self-pollinated.

Fruit or seed (grain): A carypopsis; oblong, reddish-brown with finely curved striae and fall free at maturity, broadly grooved, pericarp loose, delicate, embryo suborbicular and basal.

Varieties differ in their period of maturity, season of cultivation, habit; size, shape, colour and compactness of earhead; yielding capacity and quality of grains.

Germination: Hypogeal.

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Genus: **Setaria**

The genus Setaria comprises of 100 species, all that favour tropical and warm temperate climates.

The species belonging to Setaria are mostly annual grasses with various habits. The spikelets are subsessile in contracted, cylindrical or pyramidal terminal panicle, articulated on a very short pedicel, subtended by 1 to many persistent scabrid or barbed bristles (modified branchlets) which often form a one-sided involucel. Involucral glumes smaller and nerved. lemma more or less exceeding and resembling the upper involucral glume (Glume II); usually paleate, palea coriaceous or crustaceous, nerved, about equalling the glume. Lodicules 2, broadly cuneate. Stamens 3. Stigmas 2, laterally exserted. Grain oblong or ellipsoid, lightly enclosed by the hardened glume and palea.

Setaria italica Beauv.

Hindi: KAKUN, KANGNI, CHENA

English: Italian millet or fox-tail millet

The outstanding factor to be noted about he Italian millet is its short growing period. It matures within a period of 100 days and at the same time gives as good a yield of grain as the food grains which occupy the fields for a much longer period. It grows on areas of low rainfall ranging from 20″–30″. It can grow on a variety of soils but favours black soil. The crop can be grown throughout the year and as a minor grain crop it is undoubtedly a very useful and important crop in the dry parts of South India.

BOTANICAL DESCRIPTION

Habit: An annual cultivated grass attaining a height of 3–3½ ft.

Root: Seminal roots are produced from the grain, they are three in number and later replaced by fibrous adventitious roots.

Stem: Erect, slender, tufted, hollow at the internodes, internodal length maximum in the middle, the apical internode terminates into the inflorescence; a short furrow alternating in position at each node runs upward for a short distance at each node. Buds are present at each node but only the buds present at the basal nodes develop into tillers; true branches may arise sometimes from the upper buds.

Leaf: Linear or linear lanceolate, narrow, acuminate: light green in colour; upper surface smooth and lower ridged, with a prominent midrib; sheath densely ciliate on margin and mouth, grooved, open above and overlapping at the base. Ligule is short, thick and fimbriated. Auricles indistinct and marked by a narrow band of fine brown hairs. The flag leaf has a longer sheath with the blade either shorter or longer than the inflorescence.

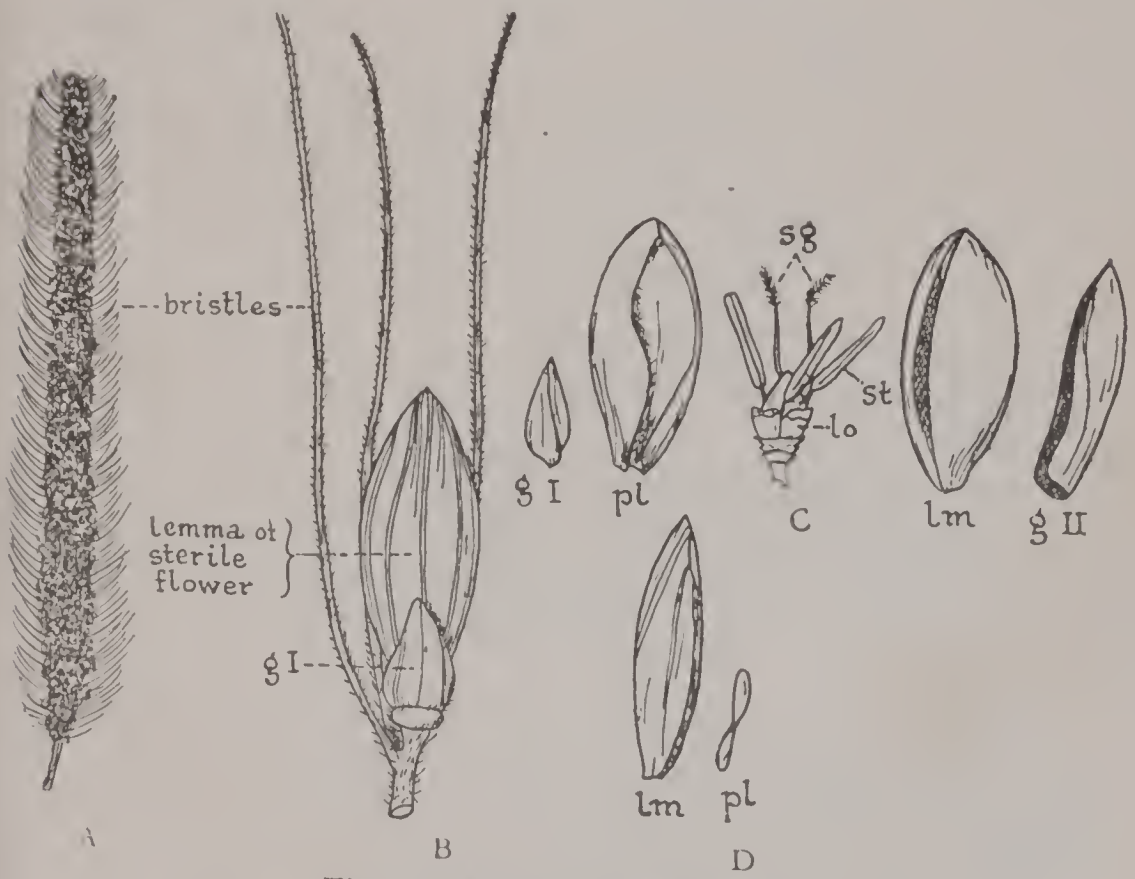

Fig 15—**ITALIAN MILLET**

A. The ear-head of Italian millet. **B.** A single spikelet. **C.** A dissected spikelet showing upper floret (perfect). **D.** The lower floret (sterile); gI, first empty glume; gII, second empty glume; lm, lemma; lo, lodicule; pl, palea; sg, stigma; st, stamen.

Inflorescence: A spike-like panicle, borne on a long slender peduncle and covered up with thin bristles; dense, inclined or nodding, simple, cylindric or lobed or compound; rachis very hairy. The branches in the spike are arranged spirally along the length and the spikelets are in clusters of 40 or 50. Spikelets oval or elliptical in small clusters on the abbreviated branchlets of the panicle, below each pedicel, bristles smooth or barbed. Involucral glumes membranous; lower—oval, pointed and 3-nerved; upper—nearly as long as the spikelet, broadly oval, pointed and 5-nerved.

Flower (floret): Each spikelet is 2-flowered lower sterile and upper perfect. The lower is represented by a hyaline lemma and a much reduced membranous palea. Lemma: more developed in the fertile flower (upper floret), 5-nerved, broadly oval and chartaceous bearing a bisexual-flower (upper) or infertile (lower). Palea: oval or elliptic or subglobose, concave and of similar texture as lemma (in upper floret).

Perianth: Lodicules 2, broad and wedge-shaped.

Androecium: Stamens 3 with bilocular versatile anthers and long filaments.

Gynoecium: Monocarpellary; ovary superior, smooth with 2 long styles, each terminating into a feathery stigma.

Floral Formula: † ☿ Gl_2 Lm_1 Pl_1 P_{Lod2} A_3 $\underline{G_1}$.

or † ☿ Br_2 Brl_2 P_2 A_3 $\underline{G_1}$

Pollination: Self-pollination is the rule, though cross-pollination also occurs to a limited extent through anemophily.

Fruit (grain):: A broadly oval, smooth and white caryopsis; the ventral surface is flattened with a dark coloured spot (hilum) at the base; the dorsal surface is convex and grooved to half its length marking the position of the embryo. Lemma and palea firmly enclose the mature grain.

Germination: Hypogeal.

Varieties differ in their duration of crop, height, vigour and yield, degree of compactness of earhead, smoothness and density of of bristles and size, colour and smoothness of the grain surface.

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CHAPTER III

Order: SPADICIFLORAE

(or SPATHIFLORAE)

The order Spadiciflorae includes herbs or climbers. Leaves are generally large, often branched with reticulate–pinnate or palmate venation (sometimes parallel). The inflorescence is typical of its kind where the minute flowers are crowded on a spike or a thickened *'spadix'* which is subtended by *'spathes'*. Perianth is usually missing, it is much reduced when present, dry or fleshy but never petaloid. The ovary is hypogynous and fruit is usually a berry with minute embryo embedded in the copious endosperm.

The order includes three important families: Palmae (Palm family), Araceae (Arum family) and Lemnaceae (Duckweed family), of which the last one has been omitted from the ensuing details.

Family: PALMAE

(Palm family)

Palmae is a large family of woody plants, mostly trees with palm-like habits. The flowers are small, trimerous, mostly on compound spadices having simple or branched rachillae and enveloped by spathaceous bracts in bud and with a superior ovary. The fruit is a berry or drupe and the seeds are endospermic.

The family includes about 140 genera and more than 1200 species, generally distributed throughout the tropics and extending somewhat in the warmer parts of the temperate zone. Due to its characteristic habits, different from Araceae and Lemnaceae, many of the authorities have put this family under a separate order **Principes** (consisting of Palmae only).

Familiar examples :

Coconut-palm or NARYAL (*Cocos nucifera*) ; sago-palm (*Metroxylon rumphii*); date-palm or KHAJOOR (*Phoenix sylvestris*); oil-palm (*Elaeis guineensis*); bettlenut-palm or SUPPARI (*Areca catechu*) ; Indian sago-palm or fishtail-palm

or toddy-palm (*Caryota urens);* fan-palm (*Livistona chinensis);* rattan-palm (*Daemonorops adspersus*).

FLORAL CHARACTERS

Inflorescence: Simple or much branched spadix (spikate or paniculate) enclosed in one or more sheathing spathes, which may be hard and woody (then called *'cymba'),* opening one by two valves, situated either amongst or below the leaves.

Flower: Generally small and inconspicuous but produced in immense numbers presenting an imposing appearance, regular, sessile or very short pedicelled; commonly unisexual with male and female flowers in the same or different inflorescences, either monoecious or dioecious, sometimes bisexual.

Perianth: Of six segments in two trimerous whorls (P_{3+3}); free or connate; sepals (outer whorl—smaller) generally imbricate or open in bud; petals (inner whorl—thick and tough) mostly valvate in staminate flower and imbricate in pistillate; greenish, white or petaloid, often woody.

Androecium (in male or bisexual flower): Mostly 6, in two series of 3 each (occasionally more or sometimes 3); anthers versatile, two celled, dehiscing by vertical slits; filaments free or connate, usually short; pollens often ellipsoid or nearly round, very rarely spinose.

Gynoecium (in female or bisexual flower): Carpels (3), syncarpous or rarely apocarpous; pistil 1 or rarely 3 and basally connate; ovary superior, unilocular or trilocular, free, ovoid or oblong or globose, developed in bisexual or pistillate flowers and rudimentary or absent in staminate ones; 3-celled (rarely 4–7); each cell one–ovuled which may be erect or pendulous but all seeds except one seed in the ovary may abort; placentation basal or axile; stigmas 3, terminal and sessile.

Floral Formulae:

Male : $\oplus\ \delta\ P_{3+3}\ A_{3+3}\ G_0$

Female : $\oplus\ \varphi\ P_{3+3}\ A_0\ \underline{G_3}$ or $\underline{(3)}$

Pollination: Often anemophilous, rarely entomophilous, pollens are produced in large quantities, self-pollination is prevented by protandry.

Fruit: Mostly dry, hard and stone-like berry or a drupe, that develops from one of the three carpels, the other two

degenerating. In many species (coconut) there is a hard fibrous coating to the fruit. The endosperm is large, especially in the coconut, where it forms the bulk of the edible portion.

Seed: Endospermic, rounded, elongated or angular, often adheres to the inner coat of the fruit.

VEGETATIVE CHARACTERS

Habit: Woody, shrubs, vines or trees. Generally palms are strikingly different from any other vegetation, with its typical straight unbranched trunks surmouted by a spreading canopy of huge pinnate or digitate leaves while a few kinds are long, trailing and woody vines.

Germination: Hypogeal.

Root: Adventitious, arising round the bulbous base of the stem; primary root short lived.

Stem: Woody, usually unbranched, may be very short or seemingly none or large bold or slender, long and flexous.

Leaf: In tree-like species (palm) they are mostly large in terminal cluster (head or coma) or scattered alternately in climbing and some shrubby species. They are petiolate, petiole stout and long, with smooth or dentate margins, the lower leaflets sometimes modified into spines and the base may be persisting or deciduous, often sheathing the trunk. Blade simple, pinnately or palmately compound. Quite often the older leaves shed off the trunk, leaving the leaf scar but in some species a little of the lower portion of the leaf base remains on the trunk after the leaf is shed giving a shaggy appearance to the column. The leaves are fan-veined (radiating from a common centre) or feather-veined.

Economic Importance:

Palmae is a family of great economic significance. It provides a number of materials for food and beverage—edible nuts, dry fruits as dessert, copra, masticatory material, mollasses and toddy. Some are important materials for several small and big industries—rattan cane, palm-sugar, sago starch, vegetable ghee, vegetable fats and oils, caranuba wax and many others. For primitive peoples of the pantropical region they rank next to grasses for providing food, shelter, clothing and innumerable lesser necessities of life. This also includes a very large number of ornamental plants used in garden and for

landscape. Hence the family is often styled as "Princes of the vegetable kingdom".

Genus: Cocos

The genus Cocos belongs to the tribe Cocoeae and includes nearly 60 species, mainly found in the tropical region. The characteristic features of the genus are: leaves pinnatisect, leaflets with reduplicate sides; spadices interfoliar, unisexual or monoecious in one inflorescence (androgynous); spathes more than one; inferior flowers often in threes, the middle one female; ovary 1–7 chambered; fruit drupe-like and large; stigma terminal, endocarp or shell hard and woody and provided with 3–7 germinating pores (eyes).

Cocos nucifera Linn.

Hindi: NARYAL *English*: Coconut

Opinion is divided about the origin of the coconut palm. Formerly it was held that the Western Hemisphere was the original home of the palm but now it is recognized that the prehistoric area between Madagascar and Philippines have been their home. Wherever there is human habitation in the numerous islands of this region, coconut is indispensable, providing a variety in food. Every part of the coconut tree is useful to those inhabitants in some form or other. Raw nut and edible copra form an important article for food, the water from the tender nut is a refreshing drink, coir goods are manufactured from the husks, shell is burnt as fuel, spoons and lables are also made out of the shell, trunk provides the fibre, fronds are utilized for thatching the roof of the huts and a sweet juice is obtained by tapping which when converted into toddy gives a mild liquor or jaggery. Copra yields an edible oil which is now-a-days used as the raw material for the manufacture of vegetable ghee, soap and toilet requisites and the charcoal from the burnt shell is sometimes much in demand for the manufacture of gas masks. In its multifarious uses mention may be made of the various modern curios made out of the ordinary coconut shells by skilled *craftsmen*.

It can profitably be grown within 20° of the equator but beyond this it becomes unproductive and cannot grow much beyond tropics even as ornamental due to its extreme sensitivity to cold. The limit of the altitude depends also on the

latitude. In Bangalore at about latitude 13° N it is grown at an altitude of 3,021 ft. It grows in areas of high temperature (the maximum on an average being above 92°F) and heavy rainfall (above 60″). It is also seen to thrive in areas with lower temperature and rainfall e.g. in Arsikere, Tiptur and Bangalore.

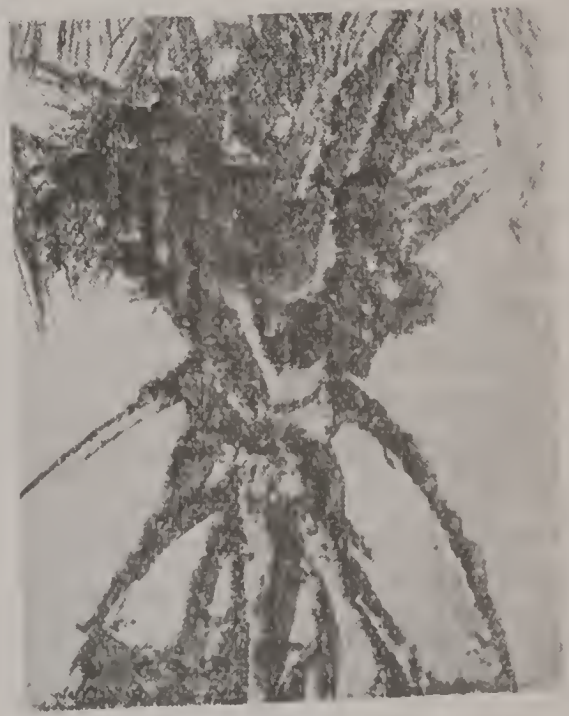
The best soil for the coconut is rich alluvium with a sufficient quantity of sand so as to provide good drainage. The largest area under it is located on the red laterite soils but good yields are also obtained in black clayey soils. It can be grown on pure white sand if underground water supply is assured, which is a matter of primary importance to the successful cultivation of the plant.

Out of the total area in India, practically the whole of the coconut area is concentrated in South India which has about 94% of its cultivation.

BOTANICAL DESCRIPTION

Habit: A tall tree, preferring much moisture and nearness to the sea characterized by its unbranched uneven stem of uniform girth, with a canopy of huge pinnate leaves on the top, forming the *head* or *crown*.

A(a)



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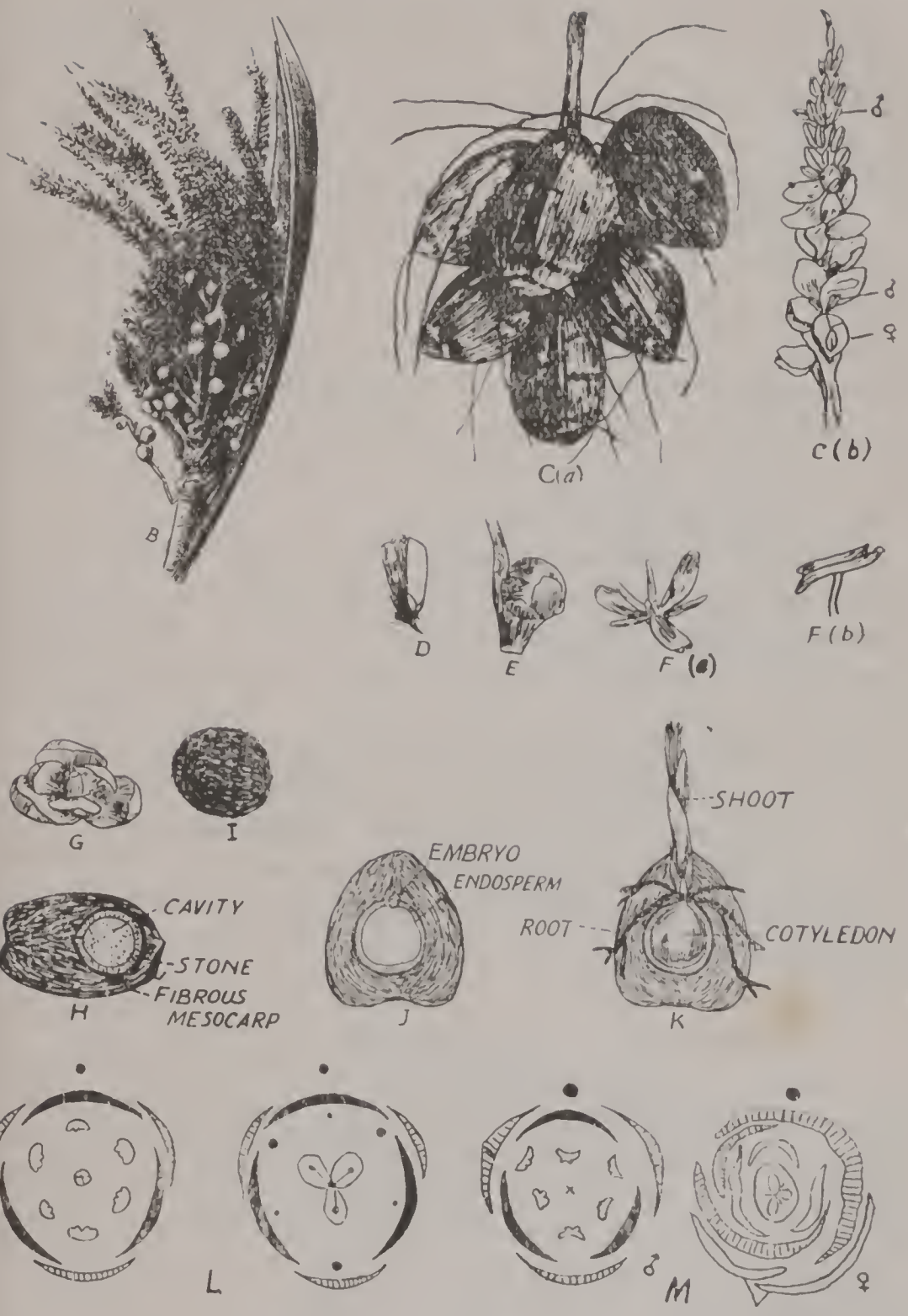

Fig. 16—**COCONUT**

A. (a) The coconut palm. (b) A coconut plant bearing fruits. **B.** An inflorescence. **C.** Stalk of inflorescence bearing a number of coconuts and sterile pedicels. (a) late stage (b) early stage. **D.** Staminate flower bud. **E.** Pistillate flower bud. **F.** (a) Staminate flower. (b) Anthers. **G.** Pistillate flower. **H.** Longitudinal section of the fruit. **I.** Coconut with husk removed, showing the three 'eyes' or 'germination pore'. **J, K.** Germination of a coconut palm. **L.** Floral diagram of palmae. **M.** Floral diagram of coconut.

Root: Adventitious, the tap-root does not persist long. The roots go considerably deep and can be classified into "water absorbing roots", "nutrient absorbing roots" and "breathing roots" in relation to their physiological function. The roots do no possess root hairs and are very rigid, strong and woody, spreading radially in all directions from the underground bole. Roots above the ground have no physiological function.

Stem: Erect, unbranched, stout, cylindrical (girth remaining more or less constant throughout the life period), with a crown of pinnate leaves at the top; with the shedding of old leaves, a rough scar is left on the trunk of the tree which gives it an uneven appearance.

Leaf: Pinnatifid and classed under *"feather-veined"* leaves (veins run out from the sides of a long midrib, the leaf being frequently divided into long narrow segments). As the trunk rises, the leaves underneath the crown die and fall, usually leaving the petiole for sometime giving a shaggy appearance to the column. A young leaf first appears at the centre of the crown as a pointed arrow, perpendicular to the ground but slowly pushed aside by the newly developing leaves. The lower portion of the young leaf is enclosed by the fibrous sheath of the next older leaf which protects it from strong wind and slowly in course of 4-5 months the whole leaf emerges out.

Inflorescence: A compound spadix, monoecious, enclosed in a tough, pointed, longitudinally grooved bract called *spathe* (inner), which is elongated, boat shaped, about the same length as the spadix and covered by a brown tomentum without. At the base of the inner spathe there is also an outer spathe nearly one-third of the length of the former and two more inconspicuous ones. There also occurs the scaly bract at the base of the spadix.

Flower: Produced in prodigious quantities, unattractive, flower parts not greatly differentiated, flowers small, unisexual, monoecious.

Male flower: Bracteate, incomplete

Perianth: Sepals 3, small, valvate. Petals 3, alternate with sepals.

Androecium: Stamens 6 in two whorls, filaments pointed

and anthers linear erect; pollens ellipsoidal with a longitudinal groove.

Gynoecium: Rudimentary as pistillode and is of 3 erect processes and centrally situated.

Female flower: Bracteate and bracteolate, much bigger than males, globose, with usually two or more male flowers on the sides.

Perianth: Segments 6, arranged in two whorls, one alternating with the other and accrescent, completely enclose the young ovary before pollination. Sepals 3, round, concave and imbricate. Petals 3, alternate with sepals and shorter, imbricate.

Androecium: Styles minute; staminodes present as a short thin ring between the base of the ovary and the perianth.

Gynoecium: Carpels (3), syncarpous; ovary superior trilocular with one ovule in each locule with sub-basilar placentation and usually only one is fertile which develops into a seed; style is minute and stigma 3.

The tendency to produce only male flowers in an inflorescence is more common when the palm produces the first few spadices. It is of usual occurrence that near the base of each lateral axis is a solitary female flower, and around the axis above it are numerous male flowers. The latter ultimately drop off leaving the now naked axis as an appendage of the fruit.

Floral Formulae:

Male : $\oplus\ \delta\ K_3\ C_3\ A_{3+3}\ G_{3\ \text{pistillode}}$

Female : $\dagger\ \varphi\ K_3\ C_3\ A_{6\ \text{staminode}}\ \underline{G_{(3)}}$.

Pollination: Coconut palms are cross-pollinated by the agencies of insects and winds. The peculiar structure of the flower and presence of honey glands attract insects to attain this.

Fruit and Seed: The coconut fruit is a large fibrous drupe which contains a single seed. The pericarp of the fruit coat is differentiated by three regions: (a) the epicarp or exocarp, forming the green covering of the fruit, (b) the fibrous mesocarp or the husk and (c) the hard endocarp or the shell. The fruit develops from the tricarpellary ovary and the three conspicuous spots or "*eyes*" at one end of the fruit are the "*germinating pores*" of the original carpels—two representing the

aborted carpels. The three ridges on the shell indicate where the edges of the three carpels met. Under the germinating pore of the fertile carpel is the *micropyle* of the seed. On breaking open the shell, a thin black layer over the kernel (white meat—*endosperm*) is the seed coat. The embryo lies as a small undifferentiated body on one of the three eyes.

Germination: When the seed germinates the embryo grows out through the germination pore. The lower end of the embryo extends and forms a single cotyledon which gradually enlarges into a spherical, spongy body and fills the whole cavity of the seed. The endosperm thins out with the growth of the cotyledon and eventually the upper end of the embryo develops into a small shoot with a number of fibrous roots produced at its base which pierce the thick fibrous coating and come out in different directions.

Notwithstanding its hard shell, thick husk and large size. physiologically the coconut is one of the most delicate seeds and is viable only about a month after it becomes ripe and is easily injured by bruising. They will even fail to germinate when kept under improper conditions.

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Family: ARACEAE (Arum family)

The family Araceae contains about 110 genera and 1900 species, most of which are tropical (92%) or subtropical and a few are found in temperate regions.

The members of this family are easily recognised from their spadix inflorescence subtended by large and brightly coloured spathes and their general tendency to prefer moist shady places.

Familiar Examples :

Taro or KACHALU (*Colocasia antiquorum*); snake palm or KANDA or SURAN (*Amorphophallus*) ; BANDA or ARVI (*Alocasia indica*) ; water cabbage or water lettuce (*Pistia stratiotes*); arum or cuckoo-pint (*Arum maculatum*); delicious monster (*Monstera deliciosa*) ; *Pothos scandens; Caladium.*

FLORAL CHARACTERS

Inflorescence: Flowers are massed together on a cylindrical 'spadix', enclosed sometimes in caducous herbaceous 'spathe' that is generally large and brightly coloured. The spadix usually terminates a joint of the sympodium so that only one is formed every year; usually monoecious with female flowers at the base, higher up some neuter flowers in some species and above them a number of closely packed male flowers; the axis of the spadix is prolonged into an *"appendage"*. The colour and form of the spathe, size and shape of the spadix with appendage are characteristic features of the genera and species.

Flower: Sessile, ebracteate, naked, small, unisexual (monoecious or dioecious) or sometimes bisexual, complete with dimerous or trimerous whorls or rarely reduced to a single stamen and carpel, regular, hypogynous or epigynous, often possesses a fetid odour.

Perianth: Rare in unisexual flowers and present in bisexual ones in the form of 4–6 free or connate segments.

Androecium: Stamens typically 6 or may be reduced in number down to one, united into a *synandrium* (Colocasia); anthers 2-celled, dehiscing by terminal pores or slit. Staminodes often present and these may also be fused into a synandrium.

Gynoecium: With much variety of structures; frequently reduced to 1 carpel, if the carpels are more (generally 1–3), they are syncarpous (*synandrodium*); ovary hypogynous, superior, when inferior it is embedded in spadix, unilocular or trilocular; each cell with one or more ovules; placentation often parietal but may be basal, axile or apical; style and stigma present and variable or absent.

Floral Formulae:

(a) $\oplus\ \mathbb{Q}\ P_{4-6}$ or $_{4-6}\ A_{1-6}$ or $_{1-6}\ \underline{G_{(1-3)}}$

(b) $\oplus\ \female\ P_0\ A_0\ \underline{G_{(1-3)}}$

(c) $\oplus\ \male\ P_0\ A_{1-6}$ or $_{1-6}\ G_0$

Pollination: Flowers usually protogynous (even when monoecious) and pollination is mainly effected by insects primarily by the flies, which often are attracted by lurid colour and offensive smell.

Fruit: A berry.

Seed: Endospermic, usually of two integuments of which the outer is fleshy.

VEGETATIVE CHARACTERS

Habit: Terrestrial herbs or occasionally climbing shrubs with epiphytic habits, preferring moist shady places but rarely aquatic. Plants are often with milky fluid sap (latex), very mucilaginous and filled with needle-like crystals of calcium oxalate. These crystals are supposed to give it a sharply pungent flavour.

Germination: Hypogeal.

Root: Adventitious and mostly formed above ground in larger forms. In epiphytes, apart from the normal adventitious roots, two kinds of aerial roots are observed—(a) climbing and (b) absorbent. The climbing or clinging roots fix the plant to its support and the absorbent or hanging roots ultimately grow down into the soil for absorption of nourishment and are frequently covered with a special water absorbing tissue.

Stem: Herbaceous, rhizomatous or tuberous and in some cases acculescent, some are vine-like and climb by aerial roots; generally sympodial and most of them contain an acrid juice or latex which in some cases are poisonous, but when heated

lose their poisonous nature and form a valuable food, rich in starch.

Leaf: Of many types but pinnately or palmately divided forms are more frequent, which are although not typical to monocotyledons with parallel venation but in any way cannot be confused with docotyledons. In certain forms holes are present (typical of aquatic habits). The leaves are mostly large, alternate, radical or cauline in climbers with distinct alternate phyllotaxy, often broad, long petioled with membranous sheathing base and reticulate-pinnate or palmate venation. The petiole is well developed which is rather unusual in monocotyledons.

Economic Importance :

The underground modified stems of many species of Araceae contain much starch and are very valuable as food and hence are grown as common vegetables (*Colocasia, Alocasia, Amorphophallus* etc.). The foliage of many of these plants are also utilized by the poor classes as green vegetables. Representatives of about 35 genera are cultivated domestically for ornamental purposes. A few of the members are declared to be poisonous while some are utilized for the preparation of drugs.

Genus: **Colocasia**

Plants belonging to the genus Colocasia are usually tuberous herbs or small shrubs or with an erect caudex, flowering and leafing together; leaves cordate-peltate, ovate cordate or sagittate cordate with a stout petiole; plant parts bear latex, accaulescent (apparently stemless). Inflorescence a spadix with stout peduncle, cylindrical, stout or slender; spathe enlarged, deciduous, contorted or twisted, spathe-tube ovoid or oblong; appendage erect, elongate conical, subulate or mucroniform. Flowers monoecious, naked and unisexual, female inflorescence at the base, male inflorescence at the top and these are interposed by the neuter. Stamens synandrous (3–6). Ovary unilocular, ovoid or oblong without style; stigma depressed with a head having 3–5 furrows; ovules many, orthotropous or anatropous. Seeds oblong with furrow, albuminous with axile embryo.

The genus Colocasia comprises of 7 species, majority of which are native to tropical countries. *C. esculenta* (Elephant's ear); *C. antiquorum* (Taro or Dasheen or KACHALU) are the two important cultivated vegetables belonging to this genus.

Colocasia esculenta Schott.

(*C. antiquorum* var. esculenta)

Hindi: KACHALU, BANDA or ARVI *English*: Taro, Dasheen

The garden in the rainy tropics always has some form of starch root, valuable as vegetable food, ready to dig. Taro is one of such ground provisions grown for its rhizomes which contain much starch. To the poor natives of the tropics it is a substitute for potato. The young leaves of some of its varieties are boiled and consumed. It is a long-season crop and grows best in damp rich but well drained, alluvial soil and needs abundant moisture.

The starch content of taro is greater than either sweet potato or potato and is considered to be a more nutritious food. Its protein content is about double and the sugar content is about one-half of the sweet potato and both are highly digestible. The sugar gives the cooked taro a sweet, nutty flavour which is much liked by the inhabitants of South China, Japan, tropical islands of the world and India. Its cultivation and use are more highly developed in Hawaiian Islands.

BOTANICAL DESCRIPTION

Habit: A perennial herb which perpetuates from its modified underground stem (rhizomes) with the onset of the growing season.

Root: Adventitious subterranean.

Stem: Herbaceous, does not grow above the ground and the plant apparently appears to be stemless or it may be slightly swollen at the base of the leaf sheaths arising from a hard tapering rhizome or in cultivated forms a tuberous rhizome: suckers and stolons sometimes present.

Leaf: Petiole erect and stout; lamina peltate-ovate, cordate at the base with a triangular sinus cut one-third to halfway to petiole; thin leathery, with bright green upper surface and paler beneath: venation reticulate pinnate.

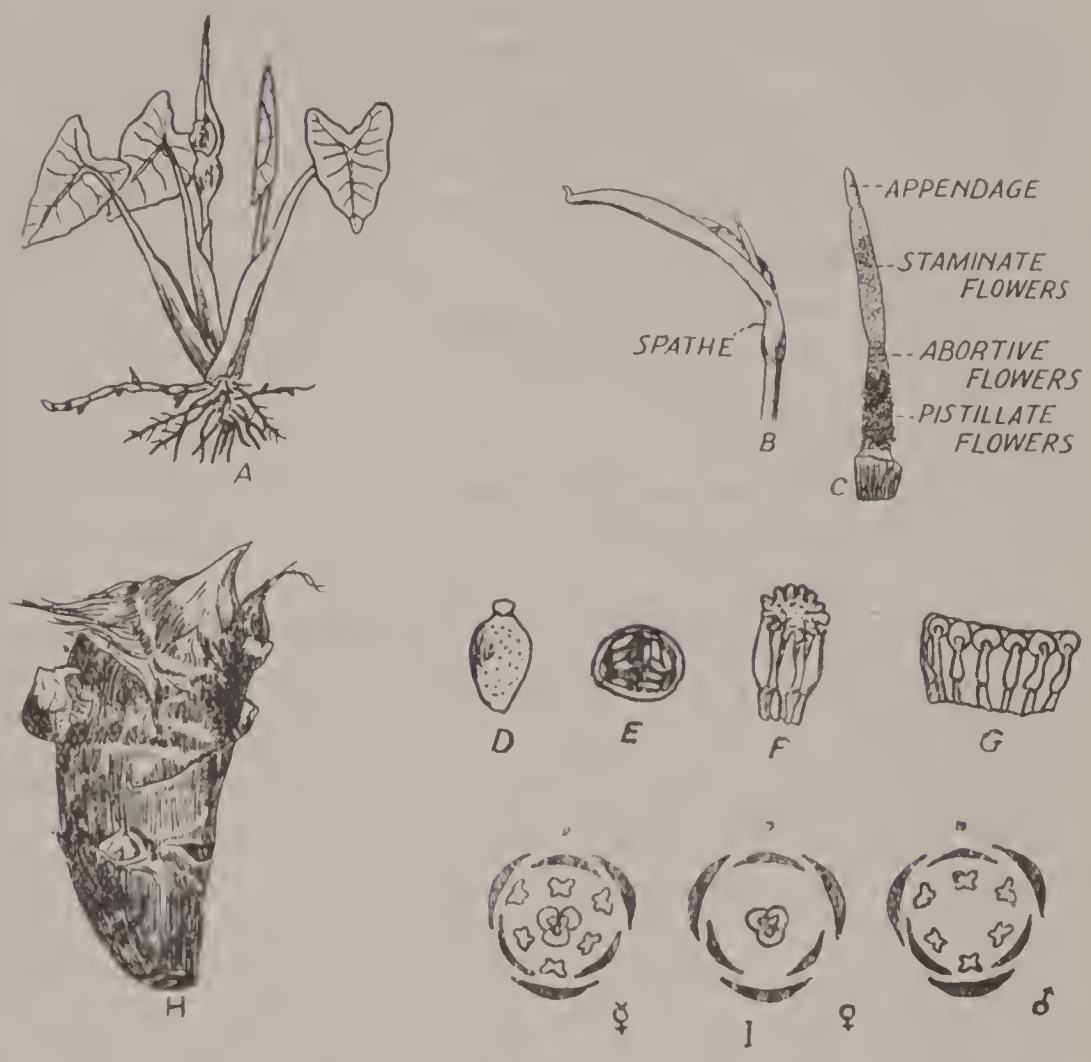

Fig. 17—**TARO or DASHEEN**

A. A plant. **B, C.** Inflorescence. **D.** Pistil. **E.** Section of ovary. **F.** Stamens in synandrium. **G.** Synandrium opened out. **H.** Rhizome. **I.** Floral diagrams of Araceae.

Inflorescence: A spadix; peduncle much shorter than the petiole. Spathe pale yellow, tube greenish, oblong; lamina narrowly lanceolate, acuminate, twisted, never widely open, curved slightly backwards in flower. Spadix much shorter than the spathe, rather slender. Appendage half as long as the staminal inflorescence and the apex is subulate. The female flowers are situated at the base and the male flowers at the top below the appendage while the neuter flowers intercalated in between them. The length of the spadix bearing female flowers is longer as compared to the sterile or male parts.

Flower: Sessile, ebracteate, naked, small, incomplete, regular, unisexual, monoecious.

Perianth: Absent.

Androecium: Present in male flowers; stamens 6, united into a synandrium, anthers 2-celled, dehiscing by terminal pore. Staminodes of female flowers also fused in a synandrium.

Gynoecium: Present in female flowers; carpel 1; ovary superior, unilocular, oblong; style very short; stigma depressed with a short head.

Floral Formula: ⊕ ♀ P_0 $A_{\text{staminodes } 6}$ $\underline{G_1}$

⊕ ♂ P_0 A_6 G_0

Fruit: Small berry.

Seed: Albuminous, oblong with furrow, embryo axile.

SPECIAL REFERENCE

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Order: LILIFLORAE

The order Liliflorae includes 6 families which generally are herbs, perennial by means of modified underground stems, rarely shrubs or trees. The order is characterized by its bisexual, regular (sometimes zygomorphic) flowers in trimerous whorls, with biseriate perianth which is usually not differentiated into calyx and corolla, with 3–6 stamens, trilocular compound ovary, having generally anatropous ovules. The fruit is a capsule or berry with endospermic seeds.

Family: LILIACEAE

(Lily family)

This family comprises of nearly 240 genera and 4000 species, cosmopolitan in distribution and abundantly found in the warm temperate and tropical regions, but no where seen to be dominant over other vegetation (except a few xerophytic representatives).

The characteristic features of the family are its modified underground stem (bulb, corm, rhizome etc.); radical or alternate leaves; trimerous, hypogynous flowers $P_{3\ 3}$ (free or fused) A_{3+3} (epiphyllous) $\underline{G}_{(3)}$.

Familiar Examples:

Lily (*Lilium* sp.), onion or PIAZ (*Allium cepa*); garlic or LASSAN (*Allium sativum*); asparagus or SATMULI (*Asparagus racemosus*); aloe or GHIKAWAR (*Aloe vera*); tulip (*Tulipa* sp.) hyacinth (*Hyacinthus orientalis*); sarsaparilla or CHOBCHINI (*Smilax macrophylla*); dagger plant or Adams' needle (*Yucca* sp.).

FLORAL CHARACTERS

Inflorescence: Various.

Flower: Regular; bisexual (rarely unisexual and then dioecious); bracteate, bracts small, scarious (thin and dry) or spathaceous; hypogynous (rarely epigynous).

Perianth: Usually petaloid (large and showy); usually 6 segments or tepals in two whorls (rarely 4 or more than 6),

not differentiated into calyx and corolla, usually gamophyllous, segments imbricate or outer series valvate.

Androecium: Stamens 6, in two whorls (rarely 3, 4 or upto 12); hypogynous or adnate to the perianth (epiphyllous); filaments distinct or connate; anthers 2–celled, basifixed or versatile, dehiscence introrse or extrorse, usually longitudinal or rarely by a terminal pore.

Gynoecium: Carpels (3), rarely more or fewer, syncarpous; pistil 1; ovary superior, trilocular with axile placentation (rarely unilocular with parietal placentation), ovules 1 to many in each cell; style 1 (rarely 3), simple, divided or trifid; stigmas 3 (sometimes 1 with 3 lobes).

Floral Formula: ⊕ ☿ P_{3+3} or $_{(3+3)}$ A_{3+3} $\underline{G_{(3)}}$

Pollination: Usually entomophilous.

Fruit: A capsule or berry; loculicidal or septicidal in dehiscence.

Seed: Endospermic.

VEGETATIVE CHARACTERS

Habit: Perennial herbs, rarely shrubs or trees; usually with rootstocks as bulb, rhizome, corm or tuber. Mostly mesophytes but some are adapted to xerophytic conditions (*Yucca, Aloe*).

Root: Usually adventitious, fibrous but sometimes tuberous (*Asparagus*).

Stem: Erect or climbing when aerial, but often modified into fleshy subterranean storage organs as rhizome, bulb, corm or tuber. In some of the xerophytes (*Ruscus, Asparagus*), the stem may be modified to phylloclades. *Dracaena* and *Yucca* show secondary growth in their woody stems, this is an exception in monocotyledons.

Leaf: Radical or cauline or both, alternate, opposite or whorled, exstipulate, mostly lamellate but sometimes reduced to scales or sheaths, or at other times fleshy, occasionally fibrous, venation usually parallel.

Economic Importance :

Liliaceae, one of the important families which includes many important vegetables, is of great commercial value, of which onion, garlic, asparagus are more notable. It is held still

higher by the floriculturists for including more than 160 genera as important domestic ornamentals. A number of them yield useful drugs—*Urginea*, *Aloe*, *Smilax* etc. A few yield fibres (*Yucca*, *Sansaviera*, *Phormium*) or resins (*Dracaena*).

Genus: Allium

Allium is the ancient Latin name for garlic. The genus consists of nearly 325 species mostly found in the temperate parts of northern hemisphere. This includes strong-scented bulbous plants, mostly cultivated in the open as vegetables (onion and their allies), but a number of them are also notable ornamentals, while a few are notorious weeds. Leaves are usually narrow, flat, channelled, or terete and fistular. Flowers white, yellow or in shades of purple and pink in a simple umbel, all at first enclosed in a 1-2 leaved membranous spathes, star-shaped or campanulate; stamens and perianth-segments 6; the perianth parts distinct or connate below, 1-nerved, and often becoming dry and persistent; stamens hypogynous or inserted on the perianth; filaments free or connate below, anthers oblong; ovary tricarpellary; style slender; stigma minute, either entire or parted cells few ovuled. Fruit a small capsule with loculicidal dehiscence. Seeds few, compressed with black testa.

Important Cultivated Vegetables of Allium :

A. cepa (Onion), *A. sativum* (Garlic), *A. porrum* (Leek), *A. ascalonicum* (Shallot). *A. schoenoprasum* (Chives), of which the first two species are of commercial importance, while the allied species are rarely cultivated in our country.

Allium cepa Linn.

Hindi: PIAZ *English*: Onion

The cultivation of Onion dates back to the remote past in India, Egypt and China. Common onion is not known to exist at present in a wild state, although claim has been made that specimens growing without cultivation are found in Arabia and Persia. The crop can be grown over a wide range of climatic conditions in the warm summer temperature of the plains and in the cold weather with a temperature of 60°F and from the sea level up to an elevation of 6000 ft. It is a hardy crop of rather dry region and a rainfall of 30″ is sufficient for

its growth. It requires a well drained loamy soil free from gravels or grit with sand predominating. For a better yield of the crop, onion needs plenty of light, a mild temperature, an optimum moisture in the pre-bulb formation stage and a bright dry weather in the ripening stage.

Onion is a common vegetable cooked independently and also along with other vegetables for flavouring. Some varieties are pickled as well. It is one of the few vegetable crops which can be preserved for a long time and can be transported to long distance, with a capacity to stand rough handling without damage, hence its importance as a comercial article.

In India, onion commands an extensive internal market and is cultivated in almost all the States in different seasons covering an area of nearly 1·5 lakh acres. Hence its availability in the market is almost throughout the year due to its ready transport from one state to the other. Thus, the *Kharif* crop of Nasik-Niphad area of Bombay State finds a ready market in the north during the winter months, when the local produce (summer harvest) is practically exhausted or unfit for consumption due to sprouting. India exports nearly 8 to 10 lakh cwt. of onion annually to various foreign countries and gets a consderable amount in return.

BOTANICAL DESCRIPTION

Habit: A cultivated biennial herb, grown for its underground bulbous stem which can also help the plant for a perennial succession. It arises in tufts or clumps.

Root: Adventitious, shallow, fibrous, new cycles of adventitious roots continue to arise from the stem throughout the life of the plant which radiate in all directions but do not penetrate deep enough.

Stem: The subterranean stem is modified into bulb which is a short, subconical structure from which the linear leaves are diverged. The terminal bud of the bulb bears a scape during flowering period which is tall, glaucous, hollow, much over—topping the leaves, inflated and leafy towards the base.

Leaf: Radical, arising from the short crown of the subterranean stem in a compact series in two rows (phyllotaxy—$\frac{1}{2}$) and consisting of a sheathing base and a blade. The sheath is fleshy, completely encircling the bulb and the younger leaves (inner) emerge through the older ones (outer) by way of a

lateral slit at the apex of each leaf base. The blades are parallel veined, cylindrical and hollow.

The major edible portion of the onion is the swollen leaf bases more or less tightly packed one over the other and surmounted on the disc-shaped flat stem. These are very rich in their carbohydrate (11–13%) and protein (1–2%) contents and are high in vitamin B and caloric values. The pungency and odour of onion is due to a volatile oil (**Allyl propyl disulphide**) which increases steadily with the maturity of the bulb and rises with the increase in average growing temperature and decrease in soil moisture or during storage.

Inflorescence: A large globular head–like terminal umbel with numerous flowers and borne by the scape. The umbel is at first enclosed in a papery spathe consisting of 2-3 bracts which is split by the development of the first flower.

Flower: Small, white or bluish, regular, pentacyclic, bisexual, hypogynous, pedicellate, protandrous.

Perianth: Segments (or tepals) 6 in two whorls of 3 each; segments ovate oblong, slightly acute and connate below; white and inferior.

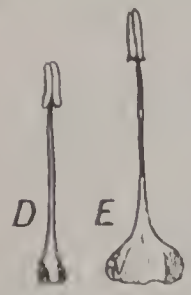
Androecium: Stamens 6, filaments longer than the perianth, connate with each other and with the perianth at its base, dilated; anthers basifixed, bilocular, protandrous, inner whorl dehiscing first, with longitudinal dehiscence; nectaries occur in the axils of the three inner stamens.

C

I(a)

I(b)

J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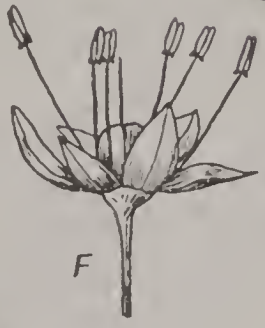
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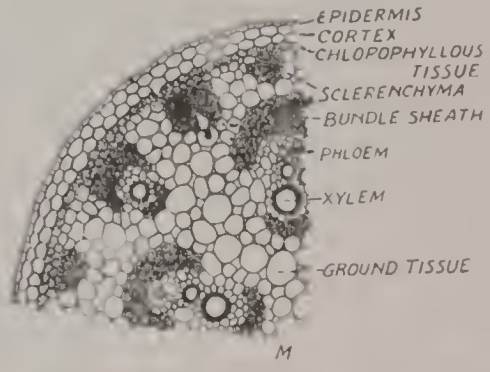
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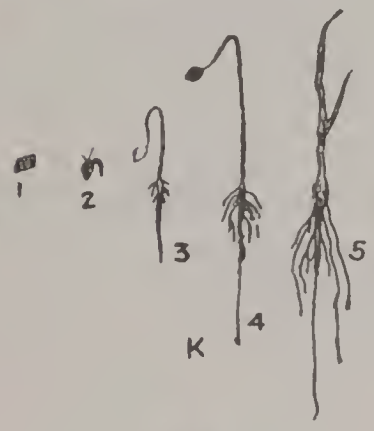
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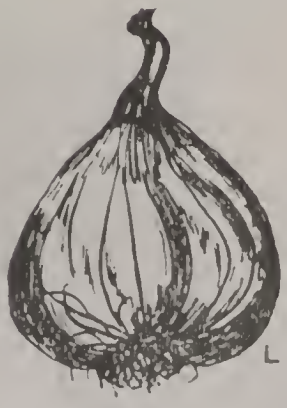
L

N

O

Fig. 18—**ONION**

A. Onion bulb with roots. B. The inflorescence. C. A portion of the inflorescence. **D.** Inner stamen. **E.** Outer stamen. **F.** A flower (side view). **G.** A flower (face view). **H.** Flower with perianth removed. **I.** (a) Pistil, with nectaries. (b) Transverse section of the ovary. **J.** Floral diagram. **K.** Stages of germination of onion seed (epigeal). **L.** Garlic. **M.** Anatomy of the flowering scape of onion. **N.** Onion plant with inflorescence. **O.** Onion in field.

Gynoecium: Carpels (3), syncarpous; ovary superior, 3-celled; ovules usually two in each cell; placentation axile; style 1, short, filiform; stigma minute and three lobed.

Floral Formula: $\oplus\ \varnothing\ \overset{\frown}{P_{3+3}}\ A_{3+3}\ \underline{G_{(3)}}$

Pollination: Cross-pollination is the rule and is effected by entomophily, although inter-pollination between flowers of the same umbel very frequent.

Fruit: A membranous capsule.

Seed: Endospermic.

Germination: Epigeal.

Temperature and photoperiod have a profound influence on the growth and flowering behaviours of onion. Relatively high temperature associated with long photoperiod is congenial for better bulb formation and discourage flowering (Heath, 1943).

Allium sativum Linn.

Hindi: LAHSAN *or* LASAN *English*: Garlic

Garlic is a native of Southern Europe. Its climatic and soil requirements are very much the same as those of onion.

It has a longer growing period of five months. It requires ample water and therefore frequent irrigation is congenial to its growth. It thrives best on fertile, well-drained loamy soils, but can grow satisfactorily on any soil on which onion grows well. It differs from onion in that it produces a group of small bulbs or cloves, instead of one large bulb, as seen in onion.

Garlic is much-used condiment and spice in Indian cookery, besides this, it has several medicinal uses and forms an important material of pharmacopoeia. It has high carbohydrate and protein contents and is rich in vitamin content and its calorific value.

The plants are of similar habits as onion but the leaves are not hollow, more or less plain, very narrow, keeled; scape slender; bulbs small, breaking up into many small ones that are more or less covered with dry scales; spathes long-beaked; flowers purple, often replaced by bulbils and thus the heads bear both bulbils and flowers; sepals lanceolate acuminate. The garlic odour is characteristically different from onion.

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PART III

DICOTYLEDONOUS CROPS

CHAPTER I

INTRODUCTORY

Characters of Dicotyledons:

The characteristic features of a Dicotyledon are that the embryo bears a pair of lateral cotyledons, generally more or less surrounded by endosperm, but at times completely filling the seed; in some cases perisperm is also present; the plumule is terminal in this case.

The plants are of various habits herbaceous or woody. Primary root persists in case of Dicotyledons and gives rise to tap root which is generally branched. The form of the leaf varies widely but a particular type is often characteristic of families or smaller divisions; with few exceptions the venation is obviously reticulate. Flowers are with pentamerous whorls but often show other arrangements as well. In germination, the radicle grows out from the seed to form a primary root. In majority of cases the cotyledons are carried above the ground (epigeal) to form the first green leaves of the plant; they are drawn out of the seed partly by the growth of the hypocotyl, partly by their own growth, the stem bud protected between them. In some cases they are hypogeal, remaining in the seed, where they act as storehouse of nourishment.

Anatomical Features:

In the stems of Dicotyledons, the vascular bundles are arranged in the form of cylinder with the pith in the centre. A cross section of such a stem shows the bundles in a circle around the pith (ectophloic siphonostele). The vascular bundles are characteristically collateral (xylem and phloem lie in the same radius, with the xylem toward the centre and phloem toward the circumference of the stem), endarch (metaxylem differentiates only outward in a radial direction from the protoxylem) and mostly open (cambium passes through each bundle and hence possesses the capacity for indefinite growth). In most species active cambium cylinder is present, and in the case of woody Dicotyledons a heavy cylinder of se-

condary wood is laid down each year (annual rings) which is responsible for the increase in thickness of the trunk.

In case of roots, the number of xylem bundles varies from 2–6 (seldom more) and the cambium soon makes its appearance as secondary meristem and gives rise to secondary growth.

Classification of Dicotyledonous Crops:

Unlike Monocotyledons, classification of Dicotyledons is more difficult due to the limitations in knowledge regarding phylogeny of plants and hence the classification that is being followed here cannot be said to be strictly phylogenetic.

In the arrangement adopted here, Dicotyledons are grouped in three grades which correspond to grades of differentiation in floral structure.

GRADE A. MONOCHLAMYDEAE OR INCOMPLETAE:

Flowers incomplete; either calyx or corolla absent or sometimes both the whorls absent; generally unisexual. The members of this grade may possibly be regarded as representing lines of development from the earlier extinct groups. It seems likely that development of the highly differentiated insect-polli nated dichlamydeous flower was preceded by such stages as shown by monochlamydeous type.

GRADE B. DIALYPETALAE OR POLYPETALAE:

Both calyx and corolla present; petals free; stamens and carpels also usually present; the former often indefinite and the latter apocarpous or syncarpous. The orders are arranged, as far as possible, in ascending sequence and the progress is indicated through polysepalous calyx to gamosepalous calyx, through indefinite number of stamens to a definite number, and through hypogyny and perigyny to epigyny.

GRADE C. SYMPETALAE OR GAMOPETALAE:

The orders of Sympetalae represent still higher grades of floral development which have sprung from various dialypetalous groups. They illustrate further developments of the tendencies to floral complexity already noticed among the Dialypetalae—calyx and corolla both present but the latter is in gamopetalous condition here and stamens almost always definite and

epipetalous. The orders of Sympetalae if systematically arranged comprise of at least three grades of development:

A. PENTACYCLICAE: a pentacyclic group, with typically two whorls of stamens.

B. TETRACYCLICAE (**Superae**): a higher group with a tetracyclic hypogynous flower.

C. TETRACYCLICAE (**Inferae**): with tetracyclic flower and an inferior ovary, in which the highest form of floral complexity is attained.

Rendle has classified the Dicotyledons into 41 orders and 174 families. Considering the important Indian crops belonging to this class, their systematic position in plant classification is shown on page 122.

DICOTYLEDONS

GRADE A. MONOCHLAMYDEAE :

GRADE B. DIALYPETALAE :

ORDER Rhoeadales — Family : **Cruciferae (Brassica, Raphanus)**

ORDER Parietales — Family : **Caricaceae (Carica)**

ORDER Peponiferae (Cucurbitales) — Family : **Cucurbitaceae (Cucurbita, Luffa, Lagenaria)**

ORDER Malvales — Family : **Malvaceae (Gossypium, Hibiscus)**

ORDER Tricoccae — Family : **Euphorbiaceae (Ricinus, Phyllanthus)**

ORDER Geraniales — Family : **Linaceae (Linum)**

ORDER Rutales — Family : **Rutaceae (Citrus)**

ORDER Sapindales — Family : **Anacardiaceae (Mangifera)**

ORDER Rosales — Family : **Rosaceae (Pyrus, Eriobotrya, Fragaria, Rosa, Prunus)**
Family : **Leguminosae (Arachis, Crotalaria, Cicer, Pisum, Phaseolus, Cajanus)**

ORDER Umbelliflorae — Families : **Umbelliferae (Coriandrum, Foeniculum, Daucus)**

GRADE C. SYMPETALAE :

I. Pentacyclicae

(a) **Superae**—ORDER : Convolvulales

Family : **Convolvulaceae (Ipomea, Cuscuta)**

ORDER : Tubiflorae

SUB-ORDER : Solanineae

Families : **Solanaceae (Solanum, Lycopersicum, Nicotiana)**
Pedaliaceae (Sisamum)

II. Tetracyclicae

(b) **Inferae**—ORDER : Companulales

Family : **Compositae (Carthamus)**

CHAPTER II

ORDER: RHOEADALES

According to Rendle the order Rhoeadales includes 1 families and is characterized by its usually herbaceous habit with scattered entire or more or less divided leaves without stipules and occurring more frequently in the temperate and cold regions. The flowers are bisexual and hypogynous with typically free cyclic perianth parts and androecium; the gynoecium is of 2-to many carpels in syncarpy but the ovary is one-chambered generally with numerous ovules and the placentation prevailingly parietal, sometimes there occurs a false septum making the ovary apparently bilocular.

Family: CRUCIFERAE (Mustard family)

Cruciferae is a large family of 350 genera and about 2500 species (178 species found in India), which are very widely distributed, but a great number of them is confined to the north temperate zone, and particularly in its cooler regions and the family is specially developed in the Mediterranean region.

It is characterized, with a few exceptions, by the presence of tetramerous perianth in three whorls (2 whorls for calyx and one whorl for corolla), cruciform petals, tetradynamous stamens, single sessile and apparently bilocular ovary with parietal placentation and the distinctive fruit (siliqua or silicula).

Familiar Examples:

Mustard or SARSON (*Brassica campestris*) ; Indian mustard or Rai (*B. juncea*); white mustard or SAFED RAI (*B. alba*); black mustard or KALI RAI (*B. nigra*) ; Indian rape or TORIO (*B. napus*); turnip or SHALJAM (*B. rapa*); cabbage or BAND GOBI and cauliflower or PHUL GOBI (varieties of *B. oleracea*) ; kohl–rabi or knol–kohl or GAND GOBI (*B. caulorapa*); radish or MOOLI (*Raphanus sativus*); garden cress or Halion (*Lepidium sativum*) ; candytuft or CHANDNI (*Iberis amara*); water cress (*Nasturtium officinale*); TARA MIRA (*Eruca sativa*).

FLORAL CHARACTERS

Inflorescence: Typically racemose, corymb or corymboraceme, rarely solitary at the end of a scape, generally without bracts or bracteoles.

Flower: Bisexual, actinomorphic (rarely zygomorphic), complete, hypogynous, cyclic (cruciform).

Calyx: Sepals 4, in two alternating dimerous whorls.

Corolla: Petals 4, usually clawed, diagonally disposed (Cruciform—like the arms of a cross), with distinct limb and claw, inferior.

Androecium: Stamens typically 6, in two whorls, usually tetradynamous—the pair of the outer whorl in a transverse plane alternating with the 2 longer pairs of the inner whorl in the median plane; filaments of each inner pair sometimes connate; glands are sometimes present at the base; anthers 2-celled and dehiscing longitudinally.

Gynoecium: Carpels (2), sometimes (4), syncarpous: ovary superior and originally unilocular but appears bilocular by the development of a false but complete septum (called replum); placentation parietal; ovules generally numerous, anatropous or campylotropous, borne on the periphery of ovary wall: style single and short; stigma bifid and generally commissural.

Floral Formula: $\oplus\ \varnothing\ K_{2+2}\ C_4\ A_{2+4}\ \underline{G_{(2)}}$

Pollination: Both cross-pollination and self-pollination occur, although autogamy is more usual; cross-pollination occurs by entomophily, particularly by nectar seeking insects, but the structure of the flower is such that the visiting insects frequently produce self-fertilization.

Fruit: Usually a siliqua or silicula with valvate dehiscence from below upwards, leaving the two placentae with the adhering seeds and the replum intact or sometimes an indehiscent one or few-seeded nut.

Seed: Attached to both sides of placentae and in most cases numerous. Testa often mucilaginous; endosperm absent; sometimes oily; the embryo is large, filling the seed and is curved.

VEGETATIVE CHARACTERS

Habit: Annual, biennial or perennial herbs, rarely woody as subshrubs and contain a pungent watery sap.

Germination: Epigeal with the cotyledons appearing above ground as the first green leaves.

Root: Tap root, sometimes modified into swollen food storage organs.

Stem: Herbaceous, rarely woody, erect, cylindrical and commonly covered with forked or stellate unicellular hairs, often very much reduced and the leaves appear to be radical with the formation of flowering stem at the time of flowering; sometimes modified to corm.

Leaf: Simple, alternate rarely sub-opposite, cauline or radical, exstipulate, frequently hairy, variously lobed and dissected.

Economic Importance:

The Cruciferae family includes several species of considerable economic importance as important food crops, oil yielders, ornamentals and also numerous common weeds. Of the important food crops (vegetables) are: cabbage, cauli-flower, broccoli, rutabaga, knol-khol, turnips, Brussel sprouts, radish and water cress, in which fleshy roots, swollen stems, leaves, inflorescences and fruits are differently utilized as vegetables. A few are important oil yielders—mustards and rape.

Eruca sativa is frequently used as condiment. Among the ornamentals nearly 50 genera are cultivated domestically.

Genus: **Brassica**

The species of Brassica are annual or biennial herbs, sometimes perennial too. The roots may be fleshy or more or less woody. The stem may be reduced or erect, branched, glabrous or slightly pubescent and sometimes glaucous. Leaves are various, the lower ones mostly lyrate or pinnatifid and the upper tend to become entire or lobed. Flowers are yellow, mostly in erect racemes; sepals erect or ascending, saccate or equal; petals long clawed; stamens 6; pistil 1 with capitate (sometimes obscurely dentate) stigmas. Fruit a long and slender pod—siliqua, compressed cylindrical or 4-sided, beaked, with a short style at the apex. Seeds are globular, yellow to brownish black, arranged in a single row in each locule, wingless, with conduplicate cotyledons.

Brassica includes many important cultivated plants: vegetables—turnip, cabbage, cauliflower, kohl rabi or knol-khol and sprouting Broccoli; oil yielders and condiment—various mustards and rape.

Brassica Campestris Prain.

Hindi: SARSON *English*: Mustard

Mustard is a coarse annual herb commonly believed to have originated in Europe. There are different varieties of mustard growing under varied climatic conditions—from hot tropics to cool temperate and even the colder climates. It can be grown on all types of soils. Of the many mustard crops cultivated in different parts of the world, SARSON, RAI, TORIO

Fig. 19—**MUSTARD**

A. (a) A radical (lyrate) leaf. (b) The plant with leaf and inflorescence. **B.** A flower. **C.** A petal showing claw and limb. **D.** Tetradynamous stamens with a young fruit. **E.** Pistil. **F.** (a), (b) A matured fruit. **G.** Fruit (siliqua) dehiscing. **H.** Floral diagram of Brassica. **I.** Floral diagram of Cruciferae

and SEOBA are most commonly grown in India. The first three are probably European in origin and Africa is believed to be the home of the last one. The mustard commonly grown in South India is the black mustard (RAI) and the other one is the common mustard (SARSON) cultivated in North India. Mustard crop is cultivated for the sake of its seed which is condiment or spice, a source of oil and also used in medicine.

BOTANICAL DESCRIPTION

Habit: A cultivated winter herb, grown for its seed.

Root: Tap-root.

Stem: Herbaceous, erect, glabrous or slightly hairy.

Leaf: Simple, alternate, radical and cauline, lyrate; basal leaves are long and petiolate, pinnatifid or lobed with a large terminal lobe and 2–4 smaller lateral lobes, margin dentate; the upper leaves have shorter petioles or are sessile, entire and oblong to lanceolate.

Inflorescence: A long raceme.

Flower: Small, regular, bisexual, hypogynous, cruciform and bright yellow coloured.

Calyx: Sepals 4, polysepalous, narrow, spreading in imbricate aestivation.

Corolla: Petals 4, free, cruciform, imbricate and with distinct claw and limb.

Androecium: Stamens 6, free, 4 inner long and 2 outer short (tetradynamous).

Gynoecium: Carpels (2), syncarpous; ovary divided into two chambers by the false septum (placental replum); placentation parietal.

Floral Formula: $\oplus \; ♀ \; K_4 \; C_4 \; A_{2+4} \; \underline{G_2}$

Pollination: Self-compatible and is normally self-pollinated.

Fruit: A narrow siliqua, opening by two longitudinal valves from base upwards, borne on short pedicels, closely appressed to the axis and abruptly contracted into a short slender beak.

Seed: Numerous, small, globose with bright brownish-red colour. The dry seed is odourless but when ground in water a pungent odour is emitted. This is due to the *"mustard oil"*

which is abundantly present in the seed. Chemically the oil is an *allylthiocyanate.*

Germination: Epigeal.

SOME CHARACTERISTIC FEATURES OF THE IMPORTANT SPECIES OF BRASSICA

B. juncea Linn. (Indian mustard or RAI):

Annual, root not tuberous, stem usually diffusely branching, leaves lobed, margins notched and angled, those on stem not clasping. The seed is an important oil yielder and a household condiment for Indians.

B. alba Linn. (White mustard or SAFED RAI) :

Tall; leaves pinnatifid or hairy; siliqua spreading, hairy, with a flat long beak, equalling or exceeding the body. The seeds yield oil.

B. nigra Linn. (Black mustard or KALI RAI) :

Stem tall and upright, with widespreading branches; leaves pinnatifid, somewhat hairy; pods short and erect, glabrous; seeds small and dark brown, pungent, supplying the mustard oil which has both medicinal and commercial value.

B. napus Linn. (Indian rape or TORIO)

The stem is erect and much branched with deeply scalloped smooth leaves, young radical leaves with scattered hairs. Root slender, not tuberous. Pedicels strongly ascending. The beak of siliqua is slender. The seeds yield "Rape oil" or "Colza oil".

In general, the residue left after oil extraction from the mustard and rape seeds are used as manure or stock food for cattles.

B. rapa Linn. (common turnip or SHALJAM) :

Leaves prominently lyrate or interrupted below; root tuberous, biennial; flowering stem stout and erect, usually not branching near base. The napiform tap root is used as vegetable.

B. oleracea Linn. (cauliflower or PHUL GOBI; cabbage or BAND GOBI; Brussel sprouts and Kale) :

This includes the general "cabbage" group with strong tap root and a reduced stem in the vegetative growth period but

elongates during flowering which bears inflorescence. Leaves are very varied at the time of vegetative growth, oblong, ovate, circular, short-stalked, fleshy with entire or waved margin: leaves of the flowering stalk is more simple and smaller. The flowers are large and long on open racemes. The pods are large and long beaked.

Among the culinary vegetables of European or American origin that have readily become popular in India, cabbage and cauliflower rank foremost. Cabbage, cauliflower, broccoli, Brussels sprout, Kohl rabi, Chinese cabbage, Kale and collards form the general group of 'cole crops' which are, in general, hardy and prefer cool weather.

Cauliflower or PHUL GOBI (*Brassica oleracea* var. botrytis Linn.) :

This is the aristocrat of the cultivated cabbages. Its soil and climatic requirements are very selective and its cultivation is localized near big cities under very fertile, moist but well drained soil. It is essentially a cool-weather crop and cultivated in India as a winter vegetable. At certain high altitudes like Ranchi (Bihar) it is cultivated throughout the year.

The tap-root is broken during the transplantation of cauliflower seedling and is replaced by large number of delicate much branched white roots which go to a maximum depth of

CAULIFLOWER

15". The plant produces a short stout stock carrying a dense terminal "head" which is a modified inflorescence with its peduncles and pedicles shortened, thickened and fleshy; the bracts and flowers are not much developed.

Cabbage or BAND GOBI (*Brassica oleracea* var. capitata Linn.):

Cabbage, one of the leading crops of the world, probably originated from the wild cabbage found along the sea coasts of Europe. Its use as a food crop has been reported by naturalists to have been in existence since earliest antiquity by the Greeks and Egyptians. It is highly placed for its food value, being rich in vitamins B and C and in minerals (especially calcium). It is hardy cool-season crop and has a wide range of soil adaptability. It is grown as a winter vegetable in India.

The orginal tap root is injured during transplantation and one of the long laterals usually assumes the positon of a tap root. The lateral root system spreads thickly in the surface layer of the soil and goes to a depth of nearly 5ft. The stem remains short during the vegetative growth period and the terminal bud develops into a compact "head" of overlapping, smooth leaves which are oblong-ovate to nearly circular in shape; smooth or glabrous; the green colour of the leaves goes on fading towards the centre of the "head". The shape of the "head", time of maturity, colour of leaves and their texture are characteristics for the identification of varieties.

(*B. caulorapa* Paso.) Kohl-rabi, Knol-kohl or GAND-GOBI or GANTH-GOBI):

A biennial plant grown for its tuberous turnip-like stem produced just above ground level. The tuber bears the glaucous and glabrous leaves with slender marginless petioles, thin blades, oval or oval-oblong, with the margins irregularly dentate and usually with 1 or 2 lobes at the base. The tuber bears conspicuous white leaf scars. It is an excellent vegetable if used before it becomes tough and stringy.

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Genus: Raphanus

The genus Raphanus comprises of about 10 species, found in Europe and temperate Asia and includes annual, biennial and infrequently perennial, branching herbs. Leaves various and variable, radical or cauline, mostly lyrate-lobed or pinnatifid. Flowers small, showy, variously coloured but generally white, yellow or reddish; slender pedicelled and in open terminal racemes; sepals erect, the lateral one somewhat saccate (pouch-like) at base; stamens usually 6, free and without appendages; style slender with slightly lobed stigma. Fruit an indehiscent siliqua, more or less constricted between the seeds with spongy tissue, long-cylindrical, fleshy or soft-corky and possessing a curved beak. Seeds globose, with conduplicate cotyledons.

Raphanus sativus Linn.

Hindi: MOOLI *English*: Radish

The origin and nativity of radish are disputable. The writings of ancient naturalists reveal that it has been cultivated since time immemorial. The Greeks were especially fond of radish and at the time of Pharaohs it was extensively cultivated

in Egypt. For geographical reasons, it is held that radish is wild in temperate Asia, probably in the oriental part, although truly indigenous radishes are doubtfully known. Whatever be their original home, radishes are now widely cultivated in many regions as popular garden vegetables for their modified thickened roots, although a few varieties also produce edible fleshy pods. Although the common radish (*R. sativus* Linn.) grows in various seasons and in a variety of soils prefers cool weather and rich, light, loose and well drained soils for its successful growth; higher temperatures (above 60°F) and heavy soils make the root hard and unpalatable. Due to its short growth period, it is commonly grown as a catch crop with other vegetables.

BOTANICAL DESCRIPTION

Habit: Behaves as annual if planted early, as a biennial when planted late. When intended for seeds it covers two seasons.

Root: The root and hypocotyl (the upper portion of fleshy primary axis, devoid of lateral roots) constitute the succulent portion of the plant which is utilized as vegetable. Basically it has a tap root system in which the main root is modified and thickened and develops into many forms (usually conical) and colours. The roots of wild varieties are less thickened and appear to be more or less fibrous. These do not penetrate deeper but obtain food through the numerous lateral roots which spread radially in all directions from the main root axis.

Stem: Reduced at the initial phase (vegetative growth period) when a rosette of leaves develops from a short crown stem but during flowering phase, the axis elongates to form an erect cylindrical, herbaceous (woody below), much branched stem which bears flowers. This is usually somewhat glaucous, sparsely pubescent with a few stiff epidermal hairs.

Leaf: Radical, cauline and ramal, simple, glabrous or sparingly pubescent; radical leaves lyrate-divided and petiolate while leaves on the flowering stalk are few, alternate (phyllotaxy 2/5), lower lyrate and upper small, oblong, sessile and auriculate; exstipulate; venation unicostate reticulate.

Inflorescence: Elongated raceme, usually ebracteate.

Flower: Small, white or rose-lilac, borne on slender pedicels, pentacyclic, hypogynous.

Calyx: Sepals 4, polysepalous, paired, the outer median pair slightly overlap the inner pair in the bud stage, erect and saccate.

Corolla: Petals 4, white or lilac, generally dark veined, polypetalous, alternately arranged with sepals, cruciform, inferior, the limb with entire or slightly extrorse margin.

Androecium: Stamens 6, polyandrous, in two whorls. The outer whorl consists of four stamens which lie opposite the sepals out of which two are functional while two appear as staminodes. The functional stamens contain nectaries at their bases. The inner whorl consists of four equal stamens which lie opposite the petals. The whole arrangement, thus, is typically tetradynamous with two short stamens in the outer whorl and four long stamens in the inner whorl. Anthers 2-celled, basifixed, with longitudinal introrse dehiscence.

Gynoecium: Bicarpellary, syncarpous; ovary superior, unilocular but apparently bilocular by the formation of a false septum (replum); placentation parietal, style short, stigma bifid.

Floral Formula: $\oplus\ \varnothing\ K_{2+2}\ C_4\ A_{2+4}\ \underline{G_{(2)}}$

Pollination: Usually self-pollinated. Insect-pollination does occur to a considerable extent.

Fruit: A siliqua, somewhat fleshy and corky, faintly or not at all constricted with a long beak equal to or exceeding the base. 1–6 seeds may be present, separated from one another by soft spongy tissue.

Seed: Numerous, minute, exalbuminous. They are small and yellowish in colour with a small double spot on one side marking the position of hilum and micropyle.

Germination: Epigeal, the cotyledons are oblong in outline, broadly notched at the tip and persist until the root attains a considerable size.

A
B
C
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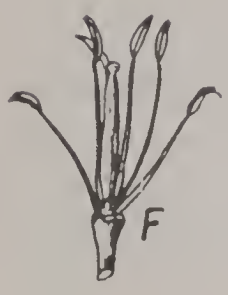
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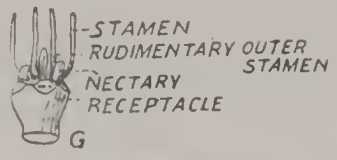
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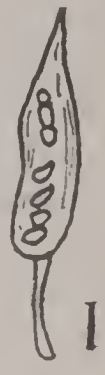
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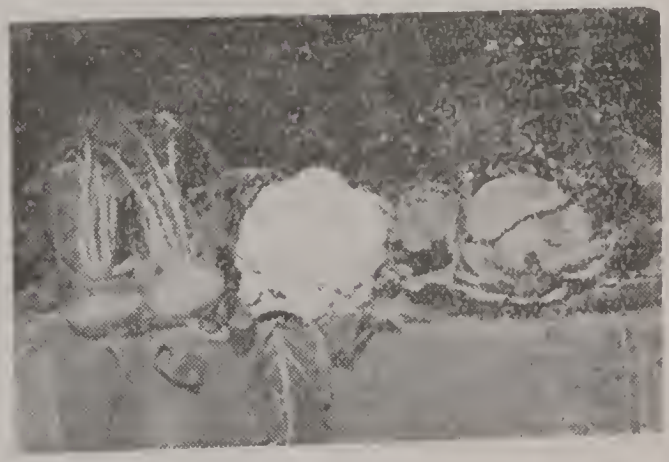

K (a)

K (b)

Fig 20—**RADISH**

A. A radical radish leaf (lyrate). **B.** The inflorescence bearing on flower stalk. **C.** The fusiform root of radish with secondary roots. **D.** Face view of a flower. **E.** Single flower. **F.** Dissected flower with perianth removed. **G.** Receptacle with perianth and two of inner stamens removed, showing location of nectaries. **H.** A portion of the stalk bearing fruits. **I.** Longitudinal section of a fruit showing seeds. **J.** Floral diagram. **K.** A few common vegetables of Cruciferae. (**a**) Turnip, cauliflower, cabbage. (**b**) Knol-Kohl, radish.

CHAPTER III

ORDER: PARIETALES

Parietales is an order comprising of 10 families majority of which are herbs or woody plants with opposite or alternate generally stipulate leaves. The circumscribed families are characterized by the flowers which are regular or zygomorphic, generally bisexual with distinct pentamerous perianth; stamens as many as the petals or more; ovary tricarpellary and unilocular, superior or more or less sunk in the floral axis, containing numerous ovules on parietal placentae; seeds generally endospermic.

Family: CARICACEAE (Papaya family)

The family Caricaceae includes 4 genera and 45 species and is predominantly found in tropical America and Africa. It is characterized by the small soft-wooded thin barked succulent trees, with an unbranched crown of long petioled alternate palmi-lobed leaves; by laticiferous vessels (milky sap); monoecious or dioecious flowers, gamopetalous corollas bearing 5 or 10 stamens and the unusual floral polymorphism.

Familiar Example:

Papaya or PAPITA (*Carica papaya*).

FLORAL CHARACTERS

Inflorescence: In general, it is axillary with dichasial branching but varies with the type of flower it bears. Male flowers are in clusters on pendant racemes; female flowers are solitary or in few-flowered corymbs.

Flower: Unisexual or bisexual, plants monoecious or usually dioecious; sessile (staminate), subsessile (pistillate).

Calyx: Sepals (5), gamosepalous, lobes short.

Corolla: Petals 5, gamopetalous (male or female) or polypetalous (female); sometimes very short or scarcely apparent.

Androecium: Stamens usually 10 in two whorls (staminate) or the inner whorl often lacking. Stamens are found to occur in three forms in case of hermaphrodite flowers: 5-hypogynous in an otherwise nearly normal female flower and the stamens are long filamented; 10-perigynous epipetalous, inserted

high up in a tube adnate to the corolla; 10-epigynous closely adnate to the ovary with their bases connected by a ridge (long fruited type). Anthers 2-celled with longitudinal dehiscence.

Gynoecium: Pistil 1; carpels usually (5), syncarpous; ovary superior, unilocular, but falsely 5-chambered by the intrusion of false septa; ovules numerous; placentation parietal; style short with 3–5 palmately branched lobes (corresponding to the number of carpels).

Floral Formula: ⊕ ♀ or ♂ or ☿ $K_{(5)}\ \overbrace{C_{(5)}\ A_{5+5}}$ or $_0\ \underline{G_{(5)}}$ or $_0$

Pollination: Entomophilous.

Fruit: A large berry.

Seed: Many with an outer sappy and inner hard testa, embryo straight and a fleshy endosperm.

VEGETATIVE CHARACTERS

Habit: Soft-wooded, herbaceous perennial with milky sap.

Germination: Epigeal.

Root: Tap-root.

Stem: Herbaceous, succulent with thin bark and unbranched.

Leaf: Foliage in a terminal crown, leaves alternate, palmately lobed, large, long-petioled, exstipulate.

Economic Importance:

The family is important for including the papaya plant which is commercially valued for its highly prized edible fruit.

Genus: Carica

The genus Carica comprises of nearly 30 species and found abundantly in the warmer parts of the globe. These are soft-wooded trees or shrubs with milky juice. The stem is simple, unbranched or with few branches bearing leaves at the apex or at the ends of the branches. Flowers pentamerous, unisexual or bisexual, monoecious or dioecious. Stamens 10, epipetalous, inserted in the mouth of corolla tube, those opposite to the lobes have short filaments while those alternating them are sessile; anthers 2-celled with longitudinal dehiscence. Ovary free, ovules numerous; placentation parietal. Fruit fleshy, sulcate, indehiscent, with numerous seeds. Seeds albuminous, straight embryo and flat, oblong cotyledons.

C. papaya is the most important species of the genus. (*C. candamarcensis* and *C. monoica* are the two other species of minor horticultural importance but they are not grown in India.

Carica papaya Linn.

Hindi: PAPITA *English*: Papaya

Papaya is a very popular sweet fruit rich in sugar and digestive enzyme and also an important source of vitamins A and C, grown abundantly in tropical countries. Apart from its use as a fruit, its use as green vegetable and preserved preparations are also no less common. The enzyme "papain", present in the milky juice of papaya fruit and other parts of the plant has been found to be highly digestive in action

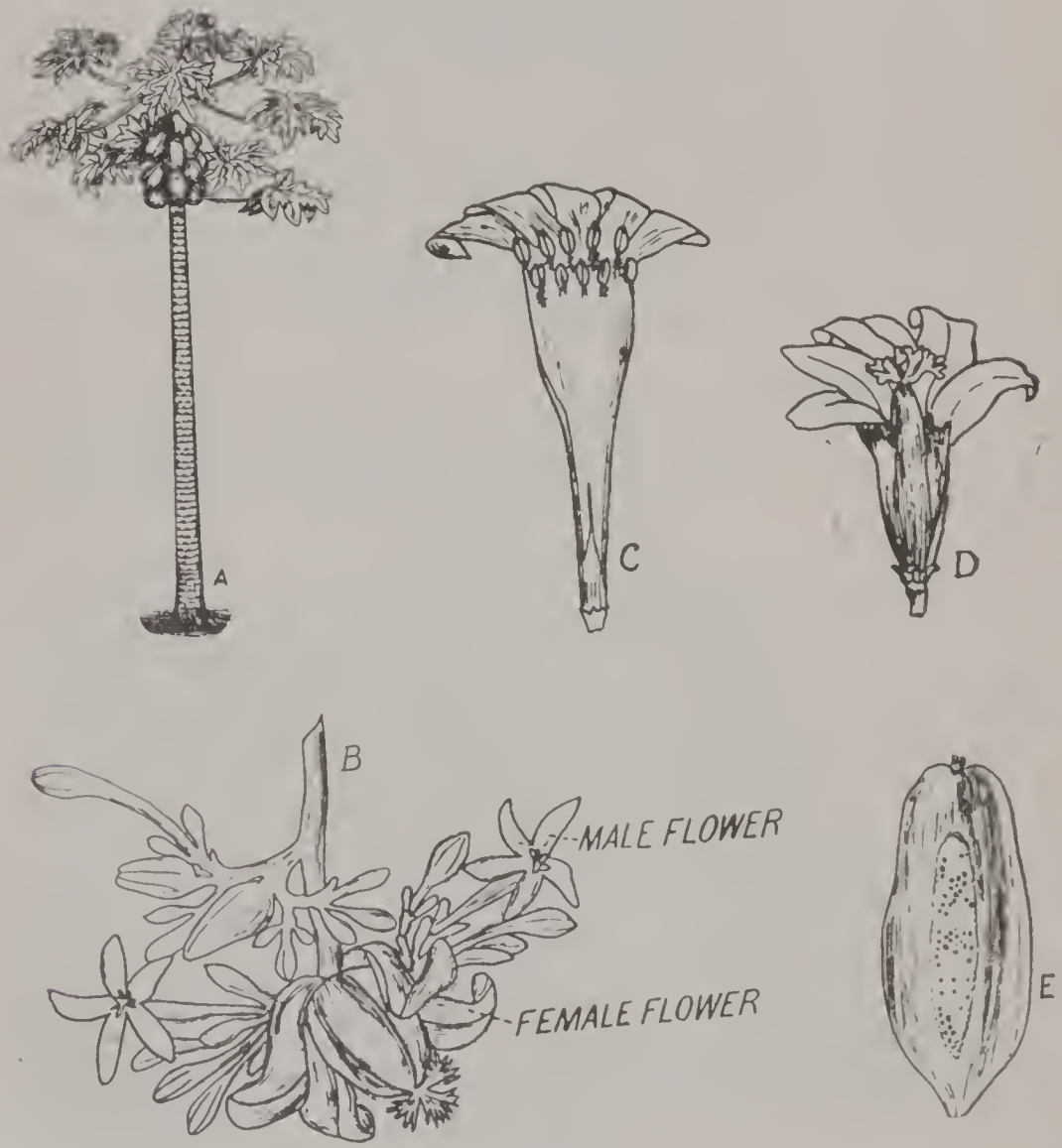

Fig. 21—**PAPAYA**

A, I. Female tree bearing fruit. **B.** Inflorescence of a monoecious plant bearing male and female flowers. C. Male flower cut open. **D.** Bisexual flower cut open. **E.** Young fruit cut open. **F.** Transection of a fruit, much enlarged as compared to E. **G.** Longitudinal section of a seed. **H.** Floral diagram of a bisexual flower.

and for softening of meat due to the presence of proteolytic enzyme. It is used as medicine as an aid to digestion and for softening of meat. During recent years, this has assumed commercial importance for the extraction of the above enzyme and in the clarification of beer.

Papaya is considered by many authorities to be a native of West Indies, the shores of Gulf of Mexico and perhaps of Brazil. It grows easily from its seed and likes plenty of moisture during its period of growth.

It succeeds best in regions of warm climate where the summer temperature ranges from 100°F to 110°F and the winter temperature does not frequently go below 40°F. A

well-drained rich loamy soil is found to be most congenial for its luxuriant growth and depth of the soil is not so important as aeration and richness in organic matter.

Papaya came to India probably in the sixteenth century from Malacca. The ease with which it is cultivated and its quick maturity give it an important place amongst the cultivated fruits in India and its importance seems to be increasing considerably.

BOTANICAL DESCRIPTION

Habit: A giant herbaceous plant, rather than a tree with milky juice (latex) and palm-like in general appearance. It is an unusually interesting plant from a botanical point of view.

Root: Tap-root, thick branches begin to come out from the base of the stem and are radially arranged on the main root axis which spread more or less horizontal to the ground surface.

Stem: Trunk is commonly unbranched, simple with foliage in a terminal crown. The wood is fleshy, the bark smooth, greyish brown, marked by prominent leaf-scars.

Leaf: Large; glabrous; palmatifid with palmate venation; petiolate, petiole long, hollow and forming a round tuft at the top of the stem.

Inflorescence: The flowers are produced in the upper most leaf axils, the staminate ones sessile on pendent racemes, the pistillate or bisexual ones subsessile and usually solitary or in few-flowered corymbs.

Flower: Unisexual (staminate or pistillate) or bisexual. imperfect or perfect, regular, pale yellow, fragrant, generally dioecious, but occasionally a few female on a male plant (monoecious). The distribution of sexes in papaya is found to be very irregular with combinations of staminate, pistillate and hermaphrodite flowers on the same and on different plants (dioecious). It has also been reported that severe injury sometimes changes the sex of papaya plant, but this occurs only on staminate trees of dioecious type.

Controversies yet remain regarding the change of sex in papaya at will (Hayes, 1953) and determination of sex at its early stage still remains to be an unsolved problem, the know-

ledge of which is essentially required for its successful economic cultivation.

Staminate flower:

Corolla: Petals (5), gamopetalous, corolla tube funnel shaped and five lobed, whitish.

Androceium: Stamens 10, epipetalous, inserted on the throat of the corolla tube, opposite the lobes on short filaments, those alternate with them are sessile; anthers adnate to the filaments, 2-celled, dehiscing longitudinally.

Gynoecium: Rudimentary or slightly developed which may give rise to small fruits.

Floral formula: $\oplus\ \delta\ K_{5)}\ \widehat{C_{(5)}\ A_{10}}\ \underline{G_{(5)}}$ rudimentary

Pistillate Flower:

This is considerably larger.

Corolla: Petals (5), fleshy, connate towards the base, linear oblong, deciduous.

Androecium: Absent.

Gynoecium: Carpels (5), syncarpous; pistil 1; ovary superior, large, cylindrical or globose, one-celled or apparently 5-celled by intrusion of false septa; ovules numerous, attached in 2–5 rows; placentation parietal, stigmas 5, fan-shaped, sessile.

Floral formula: $\oplus\ \varphi\ K_{(5)}\ C_{(5)}\ A_0\ \underline{G_{(5)}}$

Hermaphrodite Flower:

This bears perfect flowers and regularly produces good fruits. Storey (1937) has classified the perfect flowers into three distinct groups: (a) *Pentandra*—resembles the *pistillate* flowers but have 5 large stamens and produce squat fruit with deep grooves. (b) *Elongata*—have smaller elongate pistils with the petals united part way, forming a collar around the ovary and produce long narrow fruit which tend to bulge at the apex. (c) *Intermediate*—these are midway between the above two types.

Floral formula: $\oplus\ \varnothing\ K_{(5)}\ \widehat{C_{(5)}\ A_{10}}\ \underline{G_{(5)}}$

Pollination: Cross pollination is the rule and is effected by insects although self pollination also occurs to a limited extent in perfect flowers.

Fruit: The fruits of pistillate flowers are on short stems but the fruits of perfect (bisexual) flowers of polygamous trees hang on long peduncles. The fruits are fleshy, sulcate, indehiscent, commonly spherical or cylindrical, round or obscurely 5-angled in transverse section. The skin is thin and smooth outside, orange yellow or deep-orange in colour. The flesh is concolorous with the skin and encloses a large cavity which is sometimes 5-angled.

Seed: Numerous, attached to the cavity wall at the centre of the fruit; round, wrinkled, black, enclosed in sweet mucous pulp and covered with a loose hyaline gelatinous skin or arillus; testa thick, brittle; albuminous; embryo straight and flat and cotyledons oblong.

Germination: Epigeal.

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CHAPTER IV

Order: **PEPONIFERAE** (Cucurbitales)

The order Peponiferae includes 3 families and nearly 1500 species which are mostly tropical herbaceous plants, often tendril climbers. Flowers unisexual, regular and generally pentamerous, with reduction to three in the number of carpels. Ovary typically tricarpellate and inferior. Seeds lacking in endosperm.

Family: CUCURBITACEAE

(Gourd family)

The family Cucurbitaceae is represented by 100 genera and 850 species, primarily of pantropical and subtropical regions with range extensions into the temperate climates but wanting in the colder regions.

The family is distinguished by the climbing or prostrate habit, tendril bearing herbaceous juicy stems, the cordate or palmately lobed hairy leaves, the unisexual flowers with the inferior, trilocular ovary having parietal placentation and the unusual modifications of the androecium (sinuous).

Familiar Examples :

Field pumpkin or HALWA-KADDOO (*Cucurbita pepo*); squash, gourd or KADDOO (*C. maxima*) ; bath sponge or JHINGA, GHIA TORAI (*Luffa aegyptica*); NENUA (*L. cylindrica*); bottle gourd or LAUKI (*Lagenaria vulgaris*) ; muskmelon or KHARBOOZA (*Cucumis melo*); Cucumber or KHIRA (*C. sativum*), water melon or TARBOOJA (*Citrullus vulgaris*) ; bitter gourd or KARAILA (*Mimordica charantia*); snake gourd or CHICHINGA (*Trichosanthes anguina*); PARWAR (*T. dioica*).

FLORAL CHARACTERS

Inflorescence: Variable, usually axillary with cymose or modification of cymose, sometimes reduced to a solitary flower; in small flowered species, they may be racemose or paniculate;

male and female flowers may have different inflorescences. Male flowers are comparatively larger in number than the females.

Flower: Unisexual (rarely bisexual), actinomorphic, very variable in structure, pentamerous with reduction in the number of carpels, large and showy, attractive to insects due to coloured petals and nectaries—situated on the inner surface of the petals, at the base of the stamens or on the cup-shaped disc of female flowers. The flowers are epigynous, monoecious or dioecious, campanulate to rotate or salver—form in shape.

Calyx: Sepals (5), gamosepalous, calyx tube with five pointed teeth, petaloid, campanulate or funnel-shaped, odd sepal posterior, aestivation generally valvate. In female flowers, calyx tube adnate to the ovary and often produced beyond it.

Corolla: Petals (5), fused or free; when fused (gamopetalous), often deeply 5-lobed, inserted in the calyx tube, valvate or imbricate in aestivation.

Androecium: This is present only in the male flowers and is in the form of staminodes in female flowers. Primitively this consists of 5 stamens with biloculate anthers alternating with the petals, but the androecium is usually highly modified in one of the following four types, in all of which anthers are extrorse and dehiscence occurs longitudinally following the folds of the anther cells (except the fourth type):

(1) All stamens (3—5) may be all free (*polyandrous*) or four of the stamens coherent by basal portions of the filaments into two pairs, with the fifth stamen standing apart e.g. *Luffa aegyptica*.

(2) A similar situation as above, but the coherent filaments having become connate and the androecium seemingly of 3 stamens, one small (with 1-celled anther) and two large (with 2-celled anthers), e.g. *Luffa acutangula*.

(3) A situation more complex than the second is that represented by the spiral twisting of the anthers (*sinuous*) associated with their cohesion into a central column and the filaments all connate except sometimes at the extreme base (*'syngenesious'* or *'synandrous'*) e.g. *Cucurbita, Lagenaria*.

(4) The stamens strictly monadelphous with the anther locules in two horizontal ring-like pollen-containing chambers around the edge of the peltate mass of connective and filament tissues running round the top (*Cyclanthera*).

Gynoecium: This is present only in female flowers and is in the form of pistillode in male flowers. Carpels (3), syncarpous with a single pistil. The number of carpels may in some cases be more, or less than 3. Ovary inferior, typically unilocular with parietal placentation, but due to the inward growth of the placentae the ovary often appears to be three chambered with axile placentation, but the ovules are not borne in the centre because the placentae after fusing at the centre curve back, fork into two on reaching the carpellary wall and bear the ovules; ovules usually numerous; style 1 (rarely 3), short, bearing as many stigma lobes as carpels, each stigma being usually forked.

Floral Formulae:

Male : $\oplus\ \delta\ K_{(5)}C_5$ or$_{(5)}$ A_{3-5} or $_{(3-5)}$ or $_{(2)+(2)+1}\ G_0$ or (pistillode)

Female : $\oplus\ \varphi\ K_{(5)}C_5$ or $_{(5)}A_0$ or $_{3-5}$ (staminodes) $G_{(3)}$

Pollination: Entomophilous. The coloured flowers and the nectaries are the attractions for insects.

Fruit: Basically a berry, known as 'pepo', with soft or hardened pericarp, generally indehiscent and sometimes of enormous size.

Seed: Numerous, flattened with straight embryo having large cotyledons, exalbuminous with many-layered testa and oily contents.

VEGETATIVE CHARACTERS

Habit: Mostly succulent annual herbs (infrequently perennials), weak stemmed vines which may be trailing, decumbent or tendril climber. A few are shrubs or small trees. In general, they are mesophytes but cactus like xerophytes are also not rare. Many contain latex.

Germination: Epigeal; the cotyledons form the first green leaves with their typical shape and the pulled out above the ground by the elongation of the hypocotyl.

Root: Usually a branched tap-root.

Stem: Herbaceous, usually hairy all over, trailer or tendril climber, rooting at nodes, often five-angular with five corresponding bicollateral vascular bundles.

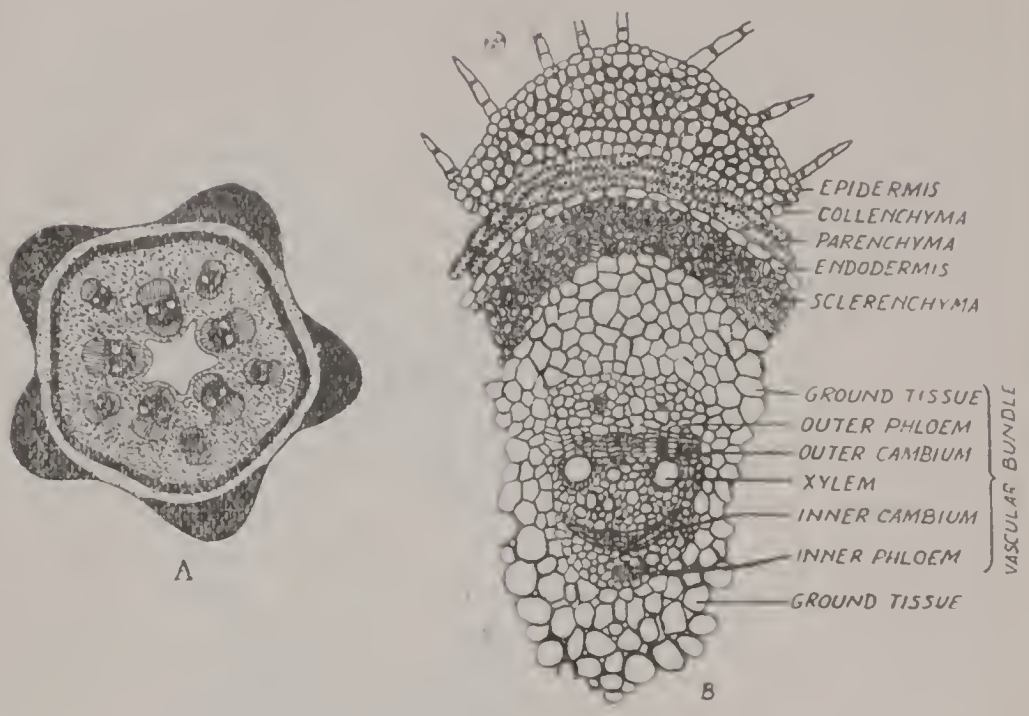

Fig. 22—**ANATOMY OF CUCURBITA**

A. Diagrammatic transverse section of stem showing distribution of bundles. **B.** Transverse section of a portion of cucurbita stem.

Anatomy of Cucurbita Stem :

A thin transverse section of a young Cucurbita stem when seen by means of a pocket lense shows the medullary cavity and arrangement of vascular bundles in two rows, the smaller ones of the outer ring correspond to ridges and those of the larger bundles of the inner ring to the furrows. The basic number of vascular bundles is ten, each cycle with five bundles, although occasionally additional smaller ones may also be present.

If a portion of the stem is viewed under a microscope, the following structures will be visible:

1. *Epidermis*: is a single layer of cells covering the outer surface and with a thin, smooth cuticle and stomata in a frequency of about 20 per sq. cm. It often bears rigid multicellular hairs on somewhat raised bases which are found to be of four types in different species of Cucurbita.

2. *Cortex*: lies below the epidermis and consists of: (a) *Collenchyma* (b) *Chlorenchyma* and (c) *Endodermis*. Chloroplasts are abundant in cortex.

Collenchyma is a narrow discontinuous band lying outside sclerenchymatous ring, which is interrupted by the underlying chlorenchyma in the furrows where the latter is seen to pass upright up to the epidermis. Endodermis is the inner most single layered tissue lying immediately outside the sclerenchyma. This is wavy in outline and contains starch grains.

3. *Sclerenchyma*: is an uninterrupted band of five or more cell layers which are lignified and polygonal in shape and whose continuity may be broken in old stems by secondary growth.

4. *Parenchyma*: lies outside the outer ring of bundles and is continuous with the medulla. This is the ground tissue and in this lie embedded the vascular bundles. The parenchyma and the adjacent fibres together represent the pericycle.

5. *Vascular bundles*: the bundles are bicollateral and each typically constitutes of: (a) two strips of cambium (outer and inner), (b) two patches of phloem (outer and inner) and (c) xylem vessels—consisting of metaxylem, protoxylem, tracheids, wood fibres and wood parenchyma.

Leaf: Alternate, broad, simple, roundish but often deeply cleft (palmati– or pinnati-partite); sometimes compound; usually exstipulate; petiolate, petioles long and hollow; venation reticulate palmate.

Morphology of Tendrils :

Tendrils of Cucurbitaceae are spirally coiled vegetative structures situated in the axil or opposite to the leaf at node, which may be simple or variously branched and help the plant in climbing up. There is much difference of opinion regarding the morphology of the tendrils. They are believed to be leaves by some, or that their branches are leaves and the main portion is the stem and by others they are considered to be bracteoles. It may be that in different genera they are of different origin.

Economic Importance :

Economically the family has domestic importance for supplying a number of vegetables (pumpkin gourds—*Cucurbita, Luffa, Lagenaria, Trichosanthes, Mimordica, Cucumbers*); edible fruits (water melon—*Citrullus;* melons—*Cucumis*) and many ornamentals (mostly as gourds). Some possess impor-

tant medicinal properties (*Citrullus colocynthis, Bryonia dioica*). The minor uses of soap-brush preparation from *Luffa aegyptica* and vessels for various Indian string instruments and snake charmer's pipe and making floats are also of considerable importance.

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Genus: **Cucurbita**

The genus Cucurbita includes about 10 species, majority of which are cultivated as vegetables. Although found abundantly in America but owing to its wide cultivation in different parts of the world the origin is doubtful.

The members of the genus are cultivated herbaceous vegetable vines; largely tendril climbers, tendril opposite to the leaf; hispid or hairy all over the stem; bearing yellow, gamopetalous, bell-shaped flowers; large solitary and monoecious. In male flowers: stamens 5, four united in pairs, the odd one remaining free; anthers connate—one 1-celled and two 2-celled. sinuous and synandrous. In female flowers: ovary oblong; style short; stigmas 3, bifid; ovules very many, horizontal; placentae 3. Fruits often large indehiscent, fleshy.

The most common species of Cucurbita known as squashes. pumpkins and gourds are:

C. pepo Linn., *C. maxima* Duch. and *C. moschata* Duch.

The nomenclature of this group of plants is very confused because of the popular English names as gourds, pumpkins, and squashes and vernacular names as KADDOO and

KOHANRA signifying at the same time the same and different species.

Cucurbita pepo, Linn.

Hindi: HALWA KADDOO, KOHANRA

English: Gourd, field pumkin or vegetable marrow

A brownish-red, globular-shaped, bluntly-ribbed gourd is a widely cultivated vegetable grown extensively in all warm and temperate parts of the globe. In India it is sown in June and July and the plant bears fruit ready for use during the cold season. It is not often cultivated in gardens. It bears fruit of enormous size for sale in the bazar where it is cut up and sold in slices. It is popular in India and is cultivated in almost all the States.

The place of origin of pumpkins and squashes is still a question of dispute and acclaimed either American or Asiatic species.

BOTANICAL DESCRIPTION

Habit: A cultivated annual vine of trailing or climbing habit.

Root: Tap-root, branched. The total absorbing system is enormous due to thick spreading of branches and branchlets. The tap root is little twisted and goes to a depth of 6 ft. or more at maturity.

Stem: Weak, herbaceous, juicy, somewhat cylindrical, ridged, prickly and hairy all over, trailing or decumbent, climbing by means of tendrils which are modified stems, laterally exserted opposite to the leaf, tip 2-3 fid.

Leaf: Petiolate, petiole long, hairy, and hollow; blade simple, orbicular to reniform in outline, palmatipartite with five shallow lobes or subentire, base cordate, sinus between the lobes narrow, apex acute, margins shallow-serrate with soft points, rough on both surfaces, venation reticulate palmate; leaves alternate, phyllotaxy 2/5.

Inflorescence: Axillary, solitary, monoecious, flowers borne on obtusely five-angular peduncles.

Flower: Large, showy, yellow with nectary glands; campanulate, pedicellate, hairy, veined, actinomorphic, incomplete, unisexual with female flowers epigynous.

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Fig. 23—**PUMPKIN**

A. Female flower. **B.** Male flower. **C.** Staminate flower without petals. **D.** Cohesion of anthers (synandrous). **E.** Longitudinal section of D. **F.** Pistillate flower without perianth and ovary. **G.** Fruit. **H.** A twig. **I.** Floral diagrams.

Calyx: Sepals (5), connate with 5 deeply inserted lobes; lobes long, linear shaped, margin entire, surface rough, apex acute, curved; calyx tube hairy, campanulate; aestivation valvate; similar in male and female flowers.

Corolla: Petals (5), gamopetalous; corolla tube with parallel sides or bulging below, 5-lobed, lobes broad and reflexed with prominent greenish veins (3 veins in each lobe), campanulate (tubular), yellow coloured, hairy inside; aestivation twisted; similar in male and female.

Androecium: Present in male flowers; stamens 5, four united in pairs, the odd one remains free; anthers connate, one 1-celled and two 2-celled, sinuous, in a synandrous condition. Staminodes are visible in female flowers.

Gynoecium: Present only in female flower; carpels (3), syncarpous; stigmas 3, each forked, brownish, fused below and free above; style cylindrical; ovary inferior, 1-celled with parietal placentation; ovules many, anatropous.

Floral Formulae:

Male : $\oplus\ \delta\ K_{(5)}\ C_{(5)}\ A_{1+(2)+(2)}\ G_0$

Female : $\oplus\ \varphi\ K_{(5)}\ C_{(5)}\ A_{3\ \text{staminodes}}\ \underline{G_{(3)}}$

Pollination: Entomophilous, attractive colour of flowers and presence of nectaries draw the insects to attain cross pollination.

Fruit: A pepo, fruiting peduncle stout, corky, striated, grooved and enlarged at junction with fruit.

Seed: Numerous, flattened with a slanting scar, slightly brownish, pointed at one end and has a thick margin. The

micropyle is at the pointed end. The seed coat consists of two-layers—the outer thick layer which becomes slimy with the imbibition of water and the inner thin layer which is delicate. The radicle lies immediately below the micropyle and the cotyledons are thin, membranous with faint veins.

Fig. 24—**GOURD (C. maxima)**

A. A twig. **B.** Male flower cut open. **C.** Female flower cut open. **D.** Synandrous condition of stamens. **E.** Pistillate flower without perianth and ovary. **F.** Longitudinal section of a pistillate flower without perianth. **G.** Transection of ovary. **H.** A matured fruit. **I.** Cross section of a fruit. **J.** Stages of germination of gourd seed (epigeal), (a)—(e). **K.** Floral diagrams of Cucurbitaceae—(a) Male flower. (b) Female flower.

Germination: Epigeal, the radicle develops first and makes its way through the micropyle after rupturing the seed coat. This forms the first primary root. The hypocotyl develops a peg-like projection which holds down the lower portion of the seed coat, and with further elongation above this peg helps in the liberation of the cotyledons from inside the seed coat. The cotyledons thus pulled out form the first green leaves. The plumule then begins to elongate and the succeeding leaves are now visible.

Genus: **Luffa**

The genus Luffa comprises about 10 species which are distributed in the warmer regions of the Old World, several are widely cultivated while others remain wild.

Luffa includes tendril climbing vines, mostly pubescent (rarely smooth) with 5–7 lobed cordate leaves without having

glands at the apex of the petiole. The flowers are either yellow or white, monoecious, male and female flowers often from the same axil. Male flowers are in racemose while female flowers are solitary. Calyx tube campanulate or turbinate with five lobes, which are tri-angular or lanceolate; this is produced beyond the ovary in case of female flowers. Petals 5, free above, joined at the base; spreading, obovate or obcordate. Stamens 3, rarely 5 (present as thick staminodes in female flowers), inserted in the calyx tube; filaments free or connate; anthers exserted, free, one 1-celled, others 2-celled, anther lobes sinuous, often on the margin of a broad connective. Gynoecium as usual, with the presence of rudimentary ovary in male flowers as glanduliform or may be absent. Fruit is oblong, smooth, angular or spinuous, not succulent, fibrous within, trilocular and terminated by the persistent style. Seeds are many which are oblong and compressed.

L. acutangula Roxb. and *L. aegyptica Mill.* are the two commonly cultivated species of the genus which produce edible fruits and grown as garden or field vegetables. The mature and dry fruits are used as sponges. The fruit and ovary of *L. acutangula* are ribbed, somewhat short as compared to *L. aegyptica* and club-shaped. *L. aegyptica*, on the other hand, produces cylindrical fruits which are not ribbed and is characterised by five free stamens while *L. acutangula* has three stamens—two 2-celled and one 1-celled.

Luffa aegyptica Mill.

Hindi: GHIA TORAI, JHINGA *English*: Loofah, Bath sponge

The native country of loofah is yet uncertain but it is found to be mostly cultivated in the tropics. It is very popular throughout India and the young fruit is relished as an everyday vegetable. There is minor use of its fibres which are a vascular bundle net of the pericarp present in the interior of the fruit and obtained after the complete drying of the latter. It furnishes the loofah or bath sponge.

BOTANICAL DESCRIPTION

Habit: An annual cultivated prostrate or climbing herb, climbing by means of tendrils which are 2–5 fid.

Root: Tap-root, branched.

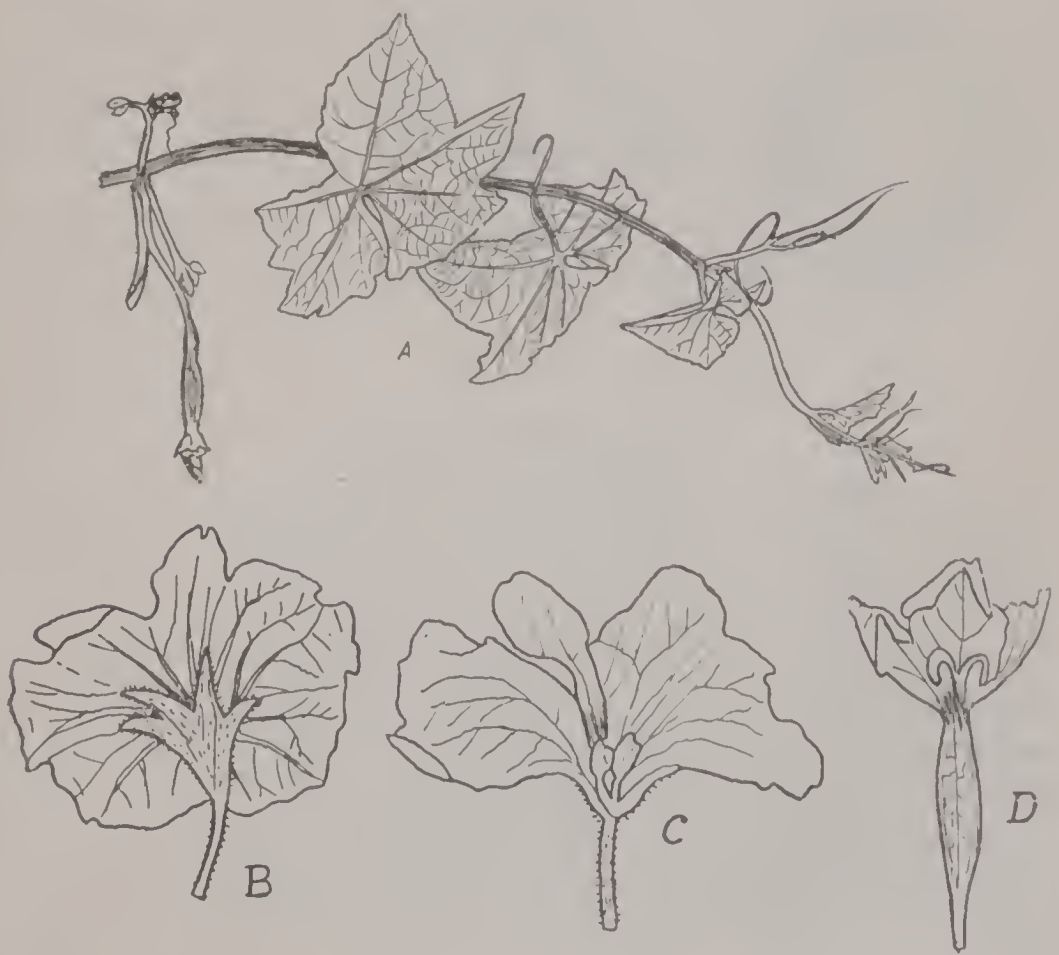
Stem: Weak, herbaceous, hairy, rough, angular, succulent and has a characteristic odour.

Leaf: Alternate, phyllotaxy 2/5; simple, reniform, orbicular, palmatifid, serrated margin, apex of each lobe acute, both surfaces rough and hairy, nerves on the dorsal surface are also pubescent; venation multicostate reticulate palmate; long petioled and bears flowers on its axil.

Inflorescence: Axillary; female flowers solitary and male flowers on short racemes with long peduncle, flowers approximate near the summit.

Flower: Yellow, unisexual, monoecious, incomplete, salverform, actinomorphic, epigynous, borne on a long peduncle. The male flowers are bracteate, bract 1, small, ovate, viscid, entire, sometimes obsolete, apex tapering.

Calyx: Sepals (5), gamosepalous, calyx tube campanulate with 5 teeth; each tooth prominently 3-nerved, spreading, apex acute, margin entire, surface slightly hairy, light yellow coloured.



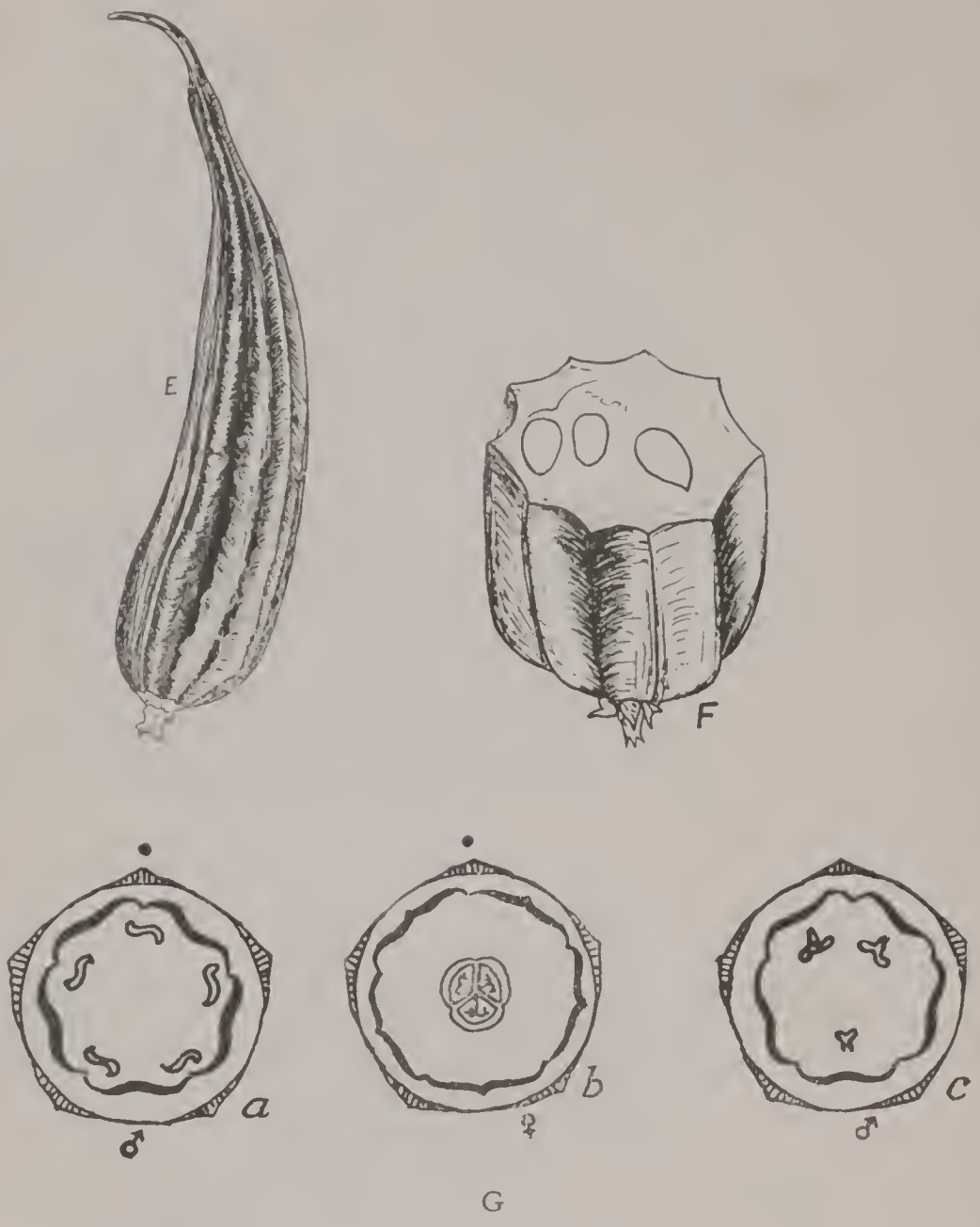


Fig 25—**BATH SPONGE**

A. A twig. **B.** Male flower. **C.** Male flower cut open. **D.** Female flower. **E.** Matured fruit. **F.** Transverse section of the fruit. **G.** Floral diagrams—a, b—*Luffa aegyptica;* c—*L. acutangata.*

Corolla: Petals (5), spreading appear to be completely free but united at the bottom; fused with the stamens in male flowers or staminodes in female flowers; petals obovate or obcordate, yellow with 5-6 prominent nerves which bifurcate towards the apex, apex obtuse, margin membranous and slightly cut at some places, uniformly covered with short soft hairs on the upper surface but confined only to the nerves on the dorsal surface.

Androecium: Present in male flowers (in female flowers as staminodes); stamens 5, free loosely fused with corolla at the base, filaments slightly dilated below, anther lobes wavy and curved (sigmoid), bilocular, yellowish with longitudinal indehiscence.

Gynoecium: Visible in female flowers; carpels (3). syncarpous, carpels united at the base but free above; style short, thick and sharp; stigmas 3, thick fleshy, hairy, sticky at maturity, each stigma forked; ovary inferior (epigynous), much elongated with about 10 lines on the surface, hairy, cylindrical, trilocular, placentation parietal—the edges of carpels meet in the centre of the ovary then curved outwards across the middle of each chamber by bifurcating near the circumference and bearing the ovules on the two incurving edges; ovules indefinite, anatropous.

Floral Formulae:

Male : ⊕ ♂ Br_1 $K_{(5)}$ $\widehat{C_{(5)}}$ A_5 G_0

Female : ⊕ ♀ Br_0 $K_{(5)}$ $\widehat{C_{(5)}}$ A_5 Staminodes $\underline{G_{(3)}}$

Pollination: By entomophily.

Fruit: A pepo (berry), long, angular, smooth, ultimately filled with fibre and three celled inside, circumsciss near the tip.

Seed: Exalbuminous, black at maturity, very narrowly winged, smooth or very sparingly tubercled.

Germination: Epigeal.

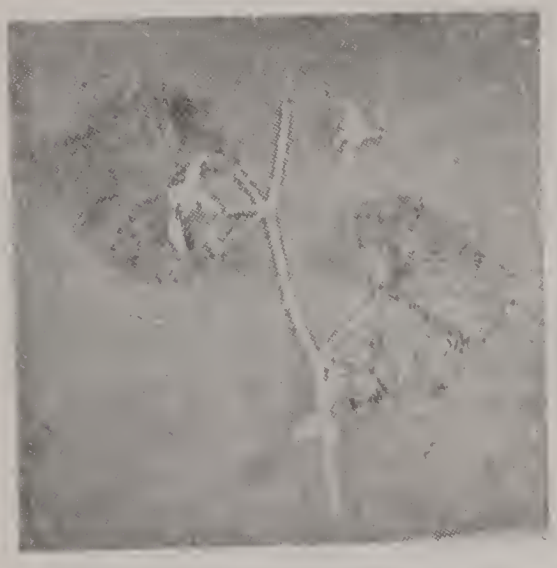
Genus: **Lagenaria**

The genus Lagenaria comprises of only one species (*L. vulgaris Ser.*) and is mostly palaeotropical. This includes tendril climbers (tendril bifid) with pubescent body; ovate or orbicular cordate, dentate, five-partite leaves with prominent hairs on both surfaces. The flowers are polypetalous, white coloured, solitary, monoecious or dioecious with three stamens in the male. Fruits are typically bottle-shaped or dumb-bell shaped and the seeds are white, smooth, compressed with a marginal groove.

Lagenaria Vulgaris Ser.

Hindi: LAUKI, LAU *English*: Bottle gourd

The bottle gourd is cultivated in the tropics and warm temperate zones of the world. This is largely grown for its



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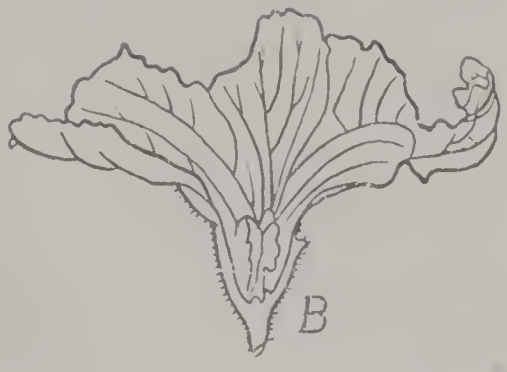

Fig. 26—**BOTTLE GOURD**

A. A twig. **B.** Male flower. **C.** Female flower. **D, E, F, G.** Cohesion of staments, in its original position and when separated. **H.** Pistillate flower after the removal of perianth. **I.** Cross section of the ovary. **J.** Matured fruit.

fruit which is a popular vegetable, the vine is also used for the same purpose. The woddy pericarp makes a flask when dried and thus can be utilized for holding water (commonly used by Indian Sadhus). In India it is widely cultivated.

It is reported as growing wild in India, Abyssinia and the Moluccas.

BOTANICAL DESCRIPTION

Habit: A long running cultivated annual vine with a sweet musky odour.

Root: Tap-root, branched.

Stem: Weak, a climbing or trailing vine angular, ridged, branched, pubescent, the degree of pubescence varies widely; tendril bifid, terminal longer than lateral, coiled.

Leaf: Petioles long with 2 glands at the apex; fleshy green, simple, cordate, lobes absent or slightly 3–7 lobed, margins serrate and hairy, apex acute; midrib prominent, venation reticulate palmate, veins swollen and prominent; the surface having silky substance, lower surface more rough.

Inflorescence: Axillary, solitary, monoecious or rarely dioecious.

Flower: Unisexual, incomplete, actinomorphic, epigynous, peduncle longer in male than female, pistillate flowers possess a large bract.

Calyx: Sepals (5), gamosepalous, free above and fused below forming 5 teeth; calyx tube funnel shaped, subcampanulate, veined–veins green coloured; sepals or teeth-linear shaped, acute apexed, entire margined and covered with small silky hairs on the surface; aestivation valvate.

Corolla: Petals (5), united, fused at the base but free above forming five deep cut lobes, whitish; veined-veins green; lobes obovate or crumpled, apex acute, margin entire, hairy on both sides, aestivation imbricate.

Androecium: Present only in male flowers, but as staminodes in female flowers; stamens 3; anthers connate including one 1-celled and two 2-celled; anther lobes sinuous and united in a central column the filaments being free (synandrous).

Gynoecium, Carpels (3), syncarpous; ovary oblong, softly pubescent, inferior (epigynous), 3-chambered; style short with 3 bifid stigmatic lobes; ovules many, horizontal; placentation apparently axile, actually parietal unilocular.

Floral formulae:

Male : $\oplus\ \delta\ K_{(5)}\ C_{(5)}\ A_{(2)+(2+1)}\ G_0$

Female : $\oplus\ \varphi\ K_{(5)}\ C_{(5)}\ A_3$ Staminodes $\underline{G_3}$

Pollination: By entomophily.

Fruit: Large, usually bottle or dumb-bell-shaped.

Seed: Numerous, white, compressed, with a marginal groove, smooth.

Germination: Epigeal.

CHAPTER V

ORDER: MALVALES

The order Malvales includes predominantly woody plants with alternate simple stipulate leaves and are found generally in the pantropical and subtropical regions. Stellate hairs are frequently present on young parts and the tissues are often mucilage producing. Flowers are bisexual, actinomorphic, cyclic, with mostly pentamerous perianth and a frequent increase in the number of members of the androecium and gynoecium; calyx valvate; stamens in two whorls, the members of the outer whorl antesepalous, often absent or reduced to staminodes, and of the inner whorl generally multiplied and monadelphous, the united filaments often forming long column round the pistil (sometimes polydelphous); ovary multicarpellate, each with 1 to many anatropous ovules with two integuments, placentation usually axile and derived from a parietal condition.

Family: MALVACEAE

(Mallow family)

The family Malvaceae circumscribes nearly 82 genera and 1500 species, which have a world-wide distribution under temperate to warm conditions, with increasing tendency towards the tropics. In the warmer parts of the earth they are often shrubby or form trees.

The most characteristic feature of the family is its androecium where the stamens are generally indefinite and monadelphous, with one celled anthers and large and spiny (echinulate) pollen grains. The leaves are simple and palminerved.

Familiar Examples:

Cotton or KAPAS (*Gossypium* sp.); red or silk cotton tree or SIMBAL (*Bombax malabaricum*); white cotton tree (*Eriodendron*); shoe flower or China rose or GURAHAL (*Hibiscus rosasinensis);* lady's finger or BHINDI (*H. esculentus);* Madras hemp or SANUKRA (*H. cannabinus*); rozella or PATUA or NALITA (*H. sabdariffa);* BAN-KAPAS (*H. vitifolius);* STHALPADMA (*H. mutabilis*); mallow (*Malva*); Hollyhock or GULE-KHERA (*Althaea*).

FLORAL CHARACTERS

Inflorescence: Solitary or compound cyme.

Flower: Regular, bisexual (rarely unisexual), hypogynous, copiously mucilaginous, with a whorl of bracts (or bracteoles) known as the "epicalyx", which may be 3 or more and distinct or connate.

Calyx: Sepals (5), united or free, persistent sometimes in the fruit along with the epicalyx, valvate, inferior.

Corolla: Petals 5, free or slightly united at the base with the androecium (staminal tube); aestivation twisted, inferior.

Androecium: Stamens (∞), in two whorls (the outer whorl usually absent), hypogynous, monadelphous (united into a bundle, known as *'Staminal tube'*), filaments apically distinct; anthers unilocular, reniform, dehiscing longitudinally and the pollen grains are distinctive, usually large and spinose.

Gynoecium: Pistil 1; carpels ($3-\infty$), syncarpous; ovary superior, many chambered, with 1 to many ovules in each chamber, usually anatropous; placentation axile, attached to the inner angle of carpel; style 1, which passes through the staminal column and apically branched or styles as many as carpels; stigmas free, as many or twice as many as carpels, often capitate.

Floral Formula: $\oplus\ \varnothing$ Epicalyx$_{(3-7)}$ K$_{(5)}$ $\overbrace{C_5\ A_\infty}$ $\underline{G_{(5-10\ \text{or}\ \infty)}}$

Pollination: Entomophilous, insects are attracted by the colour of petals and nectaries. Protandrous condition of many flowers checks self-pollination which may be a frequent occurrence in some of the small flowered species (*Malva rotundiflora*).

Fruit: Typically the fruit is dry, a loculicidal capsule, schizocarpic or sometimes a berry.

Seed: Numerous; nonendospermic or with little endosperm; embryo straight or curved; the seed coat is generally naked, but in a few species, notably in the genus Gossypium, it is densely tomentose or hairy.

VEGETATIVE CHARACTERS

Habit: Herbs, shrubs or trees, with stellate hairs on leaves and young parts and the sap is often mucilaginous.

Germination: Epigeal, the cotyledonous green leaves are cordate or reniform with an entire margin and the succeeding leaves show a gradual change from simple to lobed.

Root: A branched tap root.

Stem: Erect, herbaceous or woody with mucilaginous sap, branched and pubescently hairy.

Leaf: Alternate, simple, entire or variously lobed, usually palmately veined; stipulate, stipules 2, free lateral but as a rule fall early (deciduous).

Economic Importance:

The family is of great commercial importance as it includes the cotton plant, which is the world's greatest source of textile fibre. Cotton seeds are also valuable for yielding oil which when hydrogenated forms *"Vanaspati ghee"* and after extraction, the residue or *"oil-cake"* is used as stock feed and manure. Some species yield vegetables (e.g., lady's finger) while others possess medicinal importance (*Malva sylvestris*). There are nearly 30 genera which are grown domestically as ornamentals, more notable being, Hollyhock, poppy mallow, shoe flower and *H. mutabilis*.

Genus: **Gossypium**

The genus Gossypium includes various cottons of commerce and circumscribes nearly 30 species, found in the tropical and subtropical regions. They are grown for the fibre obtained from the woolly coma of the seeds and for the oil and pulp (meal) obtained from the seeds.

The members of the genus are tall stout herbs, or tree like bushes with large, alternate, petiolate, 3–9 lobed or entire leaves. Flowers white, yellow or purplish, provided with 3–5 large cordate calyx-like bracts (epicalyx); stamens monadelphous, ovary 3–5 chambered with 3–5 lobed style. Fruit is a loculicidally dehiscent capsule. Seeds are obovate, rounded or slightly angular, sometimes smooth, but usually covered with a short down or fuzz and a longer coat of hairs, called *"lint"*.

G. hirsutum, *G. barbadense*, *C. herbaceum*, *G. arboreum*, are some of the important kinds grown in our country.

Gossypium Sp. Linn.

Hindi: KAPAS *English*: Cotton

Cotton has been in extensive and general use in India, ever since 3000 B.C. Columbus, Captain Cook and other discoverers

found it in use in Brazil, Mexico, West Indies and other islands. The cotton culture did not reach the Mediterranean countries until the beginning of the Christian Era and the complete supremacy of cotton as a textile fibre, an article of world commerce came only in the 19th century. In the words of Dabney,* "its economic importance is far beyond numerical expression; for, while the total crop of the world is approximately ascertainable, the effect of cotton upon the commercial and social relations of mankind is too far reaching for estimation." In fact, cotton yields a number of valuable products which are indispensable to modern society. These products include cotton fibre (lint), cotton seed oil, cotton seed meal, a fibre from the stem and a drug from the roots.

Cotton is the most important species of the family Malvaceae. The plant grows throughout the world beween 40° North and 30° South in both tropical and subtropical zones. The northward limit of it is determined by its requirement of about seven months frost free weather. It needs a good summer rain, a uniformly warm summer and bright sunshine. It is grown almost all over India but primarily on the black cotton soil and on the Indo-gangetic alluvium soil. Though the yield per acre is the lowest in India when compared to other countries of the world, it has a considerable total production of 4 million tons. In the order of importance in cotton production come Bombay, Madhya Pradesh, Hyderabad, Madhya Bharat and Saurashtra.

BOTANICAL DESCRIPTION

Habit: The cultivated forms are either annual or biennial herbs while wild cottons are arborescent, shrubby or herbaceous perennials. The plants are conspicuously glandular, large glands are present on almost all the plant parts, especially on cotyledons.

Root: Tap-root with lateral branches. In general, it is shallow as compared to the size of the plant which often creates "**water-stress**" (water loss is more rapid as compared to its availability).

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*Dabney, C. W. (1896). "The cotton plant." U. S. Dep. Agr. Office of Expt. Stations. Bull. 33, Washington.

Stem: The main stem is erect, indeterminate and branched, the branches arising from the leaf axils. Branches, arranged spirally, are of two kinds—vegetative from axiliary buds and fruiting from extra-axillary buds. The vegetative branches are

Fig. 27—**COTTON**

A. A twig with leaf, flower bud and flower. **B.** Longitudinal section of flower—ov, ovary; sg, stigma; st, stamen. **C.** Cotton boll. **D.** Seed. **E.** Cross section of the ovary. **F.** Floral diagram of Malvaceae. **G.** Floral diagram of Hibiscus. **H.** Cotton plant in field.

similar in function and morphology to the primary axis, but the fruiting branches are distinctive in form, function and mode of development. Fruiting branches are more frequent on the upper portion of the stem. Change of environment may cause either kind of branch to transform into the other form.

Leaf: Petiolate, roughly cordate, 3–9 lobed, usually palmately veined, with great variations in shape, size, texture and degree of pubescence; stipulate, stipules deciduous; base pulvinus which causes leaf movements; phyllotaxy (spirally arranged) in the New world species is 3/8 (e.g. *G. hirsutum, G. barbadense*) while in the Old world species it is 1/3 or 2/5 (e.g. *G. herbaceum, G. arboreum*); the leaves on fruiting branches appear alternate in arrangement.

Inflorescence: Solitary or compound cyme.

Flower: White or yellowish or may be deep yellow at anthesis or may be brilliant red in some foreign varieties. They are large, regular, bell-shaped, borne on the fruiting branches–one to each joint; surrounded by an involucre of 3 (rarely 2 or 4) leafy bracts or bracteoles (some species have stipular bractlets) which are often persistent after the withering of the flower; hypogynous and tetracyclic.

Calyx: Sepals (5), gamosepalous; calyx tube shallow cup shaped, 5 lobed which may be long and pointed or short and broad, persistent and as the boll develops, the calyx becomes tightly adherent to its base; at the base of sepals, towards the centre there occurs a ring of nectaries made up of multicellular glands which are surrounded by stiff hairs.

Corolla: Petals 5, tubular, lobes alternating with calyx. glandular, convolute.

Androecium: Numerous, monadelphous–forming a staminal tube surrounding the pistil; filaments arise in 5 or 10 groups; anthers bilocular with longitudinal dehiscence: pollen grains large and spinose.

Gynoecium: Carpels (3–5), syncarpous; ovary superior. 3–5 chambered with 8–10 ovules in each chamber which arise in two parallel rows.

Floral Formula: $\oplus\ \varsigma\ \text{Epicalyx}_{(3)}\ K_{(5)}\ \overbrace{C_5\ A_{(\infty)}}\ \underline{G_{3-5)}}$

Pollination: Entomophilous, self-pollination also occurs to a certain extent.

Fruit (Cotton-boll): Subglobose or oval, pointed, dehiscent capsule of a shining green colour, splitting along dorsal sutures into 3–5 valves and is as long as or longer than the persistent epicalyx. In each cell of the capsule there develop either one or 7–9 seeds.

Seed: Covered with silky fibres (the staple), which form the "cotton" of commerce may be white or coloured. These hairs are the extensions of the epidermal cells of the seed coat.

Germination: Epigeal. The seedling grows rapidly and the primary root grows without branching for several days prior to the emergence of cotyledons above ground.

Cotton and other Commercial Fibres :

Cotton fibres are made up of cellulose with some protein and a little fat. There are two kinds of hairs present: (a) the **'staple'**—long hairs, lint or commercial fibre and (b) the **'fuzz'**—short hairs.

The length, fineness, number and regularity of twists, colour, degree of maturity, strength and ginning percentage differ in different varieties and greatly judge the quality of the fibre. A good quality cotton fibre is long, fine (both in feel and weight), bright white and twists often which increases the strength of the fibre.

Cotton, flax, hemp (*Cannabis sativa*), jute, sun-hemp, PATUA (*H. sabdariffa*), PATSANN (*Hibiscus cannabinus*), wool, silk and rayon (artificial silk) are fibres of commercial importance. These possess characteristic differences and can be easily identified. Cotton fibre, obtained from cotton pods, is a flat ribbon-like band with large lumen (hair cavity) and is twisted in a characteristic manner. Flax, hemp, jute, sun-hemp, and PATUA are all bast fibres and obtained after retting the stems in water. These are considerably longer, flat or cylindrical, unequal, straight, untwisted and with small lumen and thickwalls. Out of all these, flax is the finest and possesses peculiar transverse markings while hemp is peculiarly forked at its end. Coconut fibres are very coarse and rough and utilized in various coir industries. Wool fibres are entirely different in its origin (animal hairs) and possess characteristic overlapping scales. Silk and rayon fibres are distinctly different and are non-cellular, smooth, structureless, transparent and regular in diameter.

Classification of Indian Cottons:

The raw cotton is usually classified into three important grades depending on their quality—length of the staple, regularity of twist, fineness, lustre, softness, strength, colour and cleanness.

A. *Group I or Fine Cottons*: These are long staple cottons (exceed 1 inch length) and considered to be the best from the point of view of staple length and fineness. *G. barbadense*, or more commonly known as Sea Island cotton or Egyptian cotton, comes under this group which is much popular in Sindh (now in Pakistan) and Punjab.

B. *Group II or American Cottons*: These are inferior to Group I and are of the commonest and most abundant quality. *G. hirsutum* belongs to this group which has recently been introduced in many parts of our country.

C. *Group III or Native Cottons*: These are short staple cottons (less than $1\frac{1}{8}$ inch length) and are hard. Many of these are indigenous to India and are very widely distributed in this country. *G. arborium* and *G. herbaceum* are the two important representatives of this group.

G. barbadense and *G. hirsutum* are also known as New World cottons while *G. arboreum* and *G. herbaceum* as Old World cottons.

Characters of the most important cultivated species of cottons in India:

1. **G. barbadense** Linn. (Egyptian cotton):

This group of cotton is commonly known as Sea Island cotton and includes most of the long staple cottons (finest quality) of the U.S.A. and Egypt.

The plants are of medium size with varying habits from monopodial to sympodial. Branches and leaves are black-dotted and the branches are slightly purple coloured. Leaves 3–5 lobed, lobes oblong, long pointed, nearly smooth, long-stalked, usually overlapping at the base causing the sinuses to be thrown up in folds. Stipules linear-lanceolate. Flowers yellow with purple spot, on thick jointed stalks, axillary, single flowered. Bracteoles 3, very large, deeply cut, leafy, cordate. Calyx cup shaped with 5 teeth. Petals 5, not widely expanding, forming a narrow cup. Staminal tube as described earlier. Capsule

oval, long pointed, 3–5 celled, shiny, dark green, profusely pitted, with oil glands at the base of the pits. Seeds black, covered with easily separable white or brownish cotton.

2. **G. hirsutum** Linn. (American cotton):

It is becoming more popular in India and yields a medium quality cotton fibre. It has a sympodial habit with either none or very few branches. Leaves are palmatisect, with divergent and broadly triangular lobes which are unconstricted and non-overlapping at the base. Corolla widely expanding. Capsule rounded, pale green and with smooth surface. Oil glands are few and sunk beneath the boll surface.

3. **G. arboreum** Linn. (NURMA or DEO KAPAS):

This plant is of Indian origin and only grown in a limited extent in gardens. It is an arborescent or shrubby plant, rarely a herb; branches purple with scattered hairs; leaves nearly glabrous, deeply palmately 5–7 lobed, lobes linear oblong, mucronate, contracted at the base, often with a supplementary lobe in the sinus, long-stalked, stipules ensiform (sword-shaped). Flowers large, purple, rarely white on axillary, jointed, single flowered stalks. Bracteoles nearly entire, cordate, ovate, acute. Calyx 5 teethed, cup shaped. Corolla with 5 petals, which are spreading. Staminal tube antheriferous for its whole length. Capsule oblong, pointed, profusely pitted with prominent oil glands. Seeds free, covered with white wool overlying a dense, green down. Cotton not readily separable from the seed.

4. **Gossypium herbaceum** Linn. (Indian cotton or RUI or KAPAS):

This plant is of Indian origin and is cultivated widely in India to yield the cotton fibre. It is a medium sized tree with hairy or nearly smooth body. Leaves cordate 3–7 lobed, lobes broadly ovate, long pointed, long-stalked, stipules ovate lanceolate, margin smooth or toothed. Flowers regular, bisexual, yellow with a purple centre or all yellow or all purple on axillary, jointed, single-flowered stalks; bracteoles 3, large, leafy, cordate. Sepals 5, more or less connate, calyx tube cup shaped, valvate in bud. Petals 5, hypogynous, spreading, twistedly imbricate, adnate to the base of the staminal tube. Stamens in-

definite, monadelphous, forming a five-toothed staminal tube, anthers unicellular with longitudinal dehiscence. Ovary 3–5 chambered; style connate with 5 stigmas; ovules 5–7 in each cell. Fruit capsular, ovoid, dehiscing suturally in 3–5 valves (cocci). Seeds 5–7 in each coccus, ovoid, cotton white, rarely brownish, adherent to the seeds and overlying a greenish down.

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Genus: **Hibiscus**

The genus Hibiscus circumscribes nearly 160 species, found in tropical and subtropical regions. Several species are cultivated as vegetables while others as ornamentals. *H. esculentus* (lady's finger), *H. sabdariffa* (Rozella), *H. rosa-sinensis* (shoe flower) are important species of the genus.

The species are small herbs or shrubs or trees generally with large showy flowers. Leaves rounded or palmately lobed. Inflorescence generally axillary. Bracteoles 5 or more, free, connate or spathaceous. Calyx 5-toothed or 5-fid, sometimes spathaceous. Corolla of 5 petals, adnate at the base with the staminal tube. Staminal tube giving off anther-bearing filaments along its entire length; the 5 antesepalous stamens are represented by teeth at the top of the stamen-tube. Anthers reniform, one-celled. Ovary 5-chambered; styles 5, connate below, spreading above. Fruit a capsule with glabrous or hairy seeds.

Hibiscus Esculentus Linn.

Hindi: BHINDI *or* RAM-TAROI *English*: Okra *or* Lady's finger

Okra or BHINDI is a commonly cultivated vegetable of the tropics and popular in all parts of India. It is grown for its fruits which are taken when unripe. The half-ripe pods when cooked give an agreeable flavour and may be used for thickening soups and gravies, or can be taken after frying. In India, it is generally cultivated in the latter part of summer and the rains and is available when other vegetables are scarcely to be had in the garden or market. It yields a silky fibre which is sometimes used in paper making. It is considered to be Asiatic in origin and is reported to have been used by the Egyptians in the 12th century.

BOTANICAL DESCRIPTION

Lady's finger is a tall, erect, roughly hairy, annual herb (woody below when matured), growing to a height of 2-3 ft. The leaves are 8—12 inches long, 3—5 lobed, cordate at the base, lobes lanceolate oblong, coarsely toothed, rough; stalk as long as the blade, reddish; stipules linear. The inflorescence is axillary, bearing large, handsome, yellow flowers with a crimson centre on stout short stalks, shorter than the leaf stalks; bracteolate, having 8—10 bracteoles, which are linear, equal in length to the calyx and deciduous. The floral characters are similar to those as described in the genus Hibiscus. The fruit is an erect capsule which is oblong, pyramidal, tapering, horn-like, ribbed, with 6—8 ribs, smooth or coarsely hairy. Seeds are numerous with lines smooth or hairy.

Hibiscus Cannabinus Linn.

Hindi: PATWA *English*: Indian hemp

Indian hemp is the plant from which the fibre called BIMBLIPATAM jute is extracted. It is a bast fibre of great commercial value. The leaves, tops, and tender branches are valued as fodder. Its fruit and tender shoots are used as vegetable. The fibre is rough and strong and is largely used for cordage and on a small scale for sack cloth and canvas. The seeds are used as a cattle feed. It is grown on black cotton soil usually with facility for irrigation. It is also grown on clayey loams, light alluvial soils and red loams. The crop is grown

extensively in the states of Madras, Madhya Pradesh and Bombay and the fibre is produced largely for export.

BOTANICAL DESCRIPTION

A herbaceous annual with straight and simple stem and more or less glabrous. The leaves are spreading, alternate, with long, slightly prickly leaf stalk; margin serrated but the lower leaves are cordate; those in the middle are variously lobed lobes are lanceolate acute; while the leaves at the top are simply linear-lanceolate, stipulate, stipules awl-shaped. Flowers solitary, with short peduncles in the axils of the leaves; very large; yellowish with deep purple centre. Of the double calyx, the outer is 7-8 leaved, each subulate, spreading, and inserted near the base of the inner calyx. This is 5-cleft, divisions sharp-pointed, bristly and glandular near the margins, and with a large gland on the middle of each division. Stamens numerous, with their filaments united into a hollow column; anthers 1-celled, dehiscing by transverse slit. Styles equal in number to the ovaries and rising through the staminal column; carpels joined into a 5-celled, 5-valved capsule with few seeds in each cell.

SPECIAL REFERENCE

Royle, J. F. (1855). "Fibrous plants of India." Smith Elder Co., London.

Family: TILIACEAE

The family Tiliaceae contains 41 genera and about 400 species, mostly of tropical distribution with a few extensions into temperate regions. The family is easily distinguished by its nearly distinct stamens with bilocular anthers and typically cymose inflorescence.

Familiar Example:

Jute or PAT (*Corchorus sp.*).

FLORAL CHARACTERS

Inflorescence: Cymose.

Flower: Regular, bisexual, pentamerous.

Calyx: Sepals (5), rarely 3-4, free or basally connate, valvate.

Corolla: Petals as many as sepals or lacking, sometimes sepaloid, free, imbricate.

Androecium: Stamens 10 to numerous; as a rule, connate at the base only or quite free, epipetalous or may be raised above the corolla by the development of an internode (*androgynophore*); anthers bilocular, dehiscing by apical pores or longitudinally.

Gynoecium: Pistil 1; the number of carpels vary widely (2—10 or more); ovary superior with as many chambers as the number of carpels, placentation axile; ovules one to several in each locule, ascending or pendulous, more or less anatropous: style 1; stigmas usually as many as locules.

Floral Formula: $\oplus\ \mathfrak{P}\ K_{(5)}\ \overbrace{C_5\ A_{10-\infty}}\ \underline{G_{(2-\infty)}}$

Pollination: Pollination is effected by the visits of insects which are attracted by strong scent and nectaries. Self-pollination is prevented by protandry.

Fruit: Fleshy or dry, dehiscent or indehiscent and of various types.

Seed: Endospermic and with straight embryo.

VEGETATIVE CHARACTERS

Habit: Generally trees or shrubs, a few are herbaceous (*Corchorus*).

Root: Tap-root.

Stem: Woody or herbaceous, with mucilagenous cells in the pith and cortex.

Leaf: Alternate, entire, dentate or lobed, simple, often deciduous and stipulate.

Economic Importance:

The only genus of great commercial importance in this family is Corchorus which is cultivated in the tropics for their tenacious bast fibres which yield jute. The bast of Tilia (Lime-tree or Linden) is also a popular "*bast*" of the gardener. The family includes many species of domestic importance grown for ornament and shade.

Genus: **Corchorus**

The genus Corchorus consists of 40 species, mostly found in the warmer parts of the globe. These are herbs or under-shrubs with simple, serrate leaves in which the lower pair of teeth are usually much prolonged into filiform appendages. Flowers are small, yellow, bracteate: sepals 4-5: petals 4-5, with

no glands at the base; stamens numerous, on a short torus; ovary 2–5 chambered, ovules many in each chamber; style short. Fruit, a capsule, elongated or subglobose, echinate or muricate, usually beaked, 2–5 valved, sometimes transversely septate between the seeds. Seeds numerous.

C. olitorious and *C. capsularis* are the two important cultivated species of Corchorus grown as jute crops. Morphologically these two species are different and can be easily identified. *C. olitorious* is taller, with dark green, mucilaginous, sweetish leaves which are used as spinach; the flowers are bigger and the pod is cylindrical, bearing dark green seed. *C. capsularis*, on the other hand, bears bitter leaves which are used as a bitter tonic and the dried leaves are sometimes kept in households for this purpose; pods are round or oval bearing copper-brown seeds.

Corchorus olitorious Linn.

Hindi: PAT *English*: Jute

Jute is the cheapest of all the stalk fibres and is of great commercial importance. Practically all the world's supply of jute comes from the Ganges valley in East Pakistan. It is a coarse fibre that will not bleach but dyes well, and although strong, perishes when exposed.

East Bengal, in East Pakistan has the right combination of fertile soil, rainy tropical climate flooded land and abundant supply of labour to make a crop of this tropic plant. It is also grown considerably in Bihar, Orissa and Assam. The crop is at its best where the temperature is 80°F and above and the rainfall is between 60″–80″ during its growing period. Jute has long been in use in India as a gunny sack produced by hand looms. In the present day gunny sacks hold an important position in world trade. Jute is also used in the manufacture of hessain and canvas. Jute owes its lead among the minor textile fibres to its cheapness which is due partly to the great production per acre and partly to the ease with which it can be prepared, spun and woven by moderate methods.

BOTANICAL DESCRIPTION

Habit: Jute as seen in India is a herbaceous annual about 10 ft. high with erect habit. A similar plant, named as pot herb or Jew's Mallow of the Mediterranean region, grows only a foot or two.

Root: Tap-root.

Stem: Smooth, cylindrical, more or less branched.

Leaf: Lively green, smooth, alternate, petiolate, oval or oval-lanceolate, acute apexed with serrated margin and with two lower pair of teeth terminated by a cylinder filament. The leaves are mucilaginous, sweetish and are used as a spinach. Usually stipulate, stipules simple, awl-shaped and reddish at the base.

Inflorescence: Condensed cyme, flowers borne on a peduncle.

Flower: Small, yellow or pale yellow, bracteate.

Calyx: Sepals (5), gamosepalous, valvate.

Corolla: Petals 5; torus or nectary cup-shaped with glands at the base of petals.

Androecium: Stamens numerous, surrounding the stigma, connate at the base, epipetalous; anthers bilocular, dehiscing by apical pores.

Gynoecium: Pistil 1; carpels (5); ovary superior, 5-chambered with several ovules in each chamber; placentation axile: style 1, short; stigmas 5.

Floral Formula: $\oplus \; \varnothing \; K_{(5)} \, C_5 \, A_{(\infty)} \, \underline{G_{(5)}}$

Pollination: Entomophilous.

Fruit: A loculicidal capsule, dry, cylindrical, 10-ribbed, 5-locular formed of 5-valves with 5 terminal points.

Seed: Numerous, dark green, with nearly perfect transverse partitions between them, endospermic with a straight embryo.

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CHAPTER VI

ORDER: TRICOCCAE

According to Rendle, the order Tricoccae includes three families while Engler and Diels have not treated this as a separate order, but have rather included it under Geraniales. Majority of the species under this order are found to be in Euphorbiaceae family and characterized by unisexual or rarely bisexual flowers which are hypogynous, regular and with a single whorl of free perianth leaves, sometimes naked. The stamens are generally equal in number to and opposite the perianth leaves. Pistil consists of three carpels forming a three-chambered ovary and each chamber contains one or two pendulous anatropous ovules with a ventral (rarely dorsal) raphe. The pollination is usually anemophilous.

Family: EUPHORBIACEAE

It is a large family of 283 genera and about 7300 species, cosmopolitan in distribution but mainly tropical and extending into the temperate regions. India has nearly 444 species.

The most outstanding characters of the family are—the presence of latex or milky sap; alternate stipulate leaves; inflorescence often a cyathium but much variable; flowers regular, unisexual, hypogynous with superior and trilocular ovary with axile placentation; stigma bifid; fruit schizocarpic; seed albuminous.

Familiar Examples:

Castorbean or RERI (*Ricinus communis*); emblic myrobalan or AMLA (*Phyllanthus emblica*); garden croton (*Codiaeum variegatum*); tapioca (*Manihot utilissima*); walnut or AKROT (*Aleurites moluccana*); tungtree (*Aleurites fordii*); and the various spurges (*Euphorbia*).

FLORAL CHARACTERS

Inflorescence: Various, often a compound racemose or cymose, or mixed, or a cyathium as in Euphorbia which

may again be closely crowded and arranged in spike or standing in the axils of the upper leaves.

Flower: Small, bracteate, regular or slightly zygomorphic, hypogynous, unisexual, monoecious or dioecious; rudiments of the other sex are sometimes present; sometimes much reduced by abortion.

Perianth: In 1-2 whorls, sometimes absent, dissimilar in male and female flowers; valvate or imbricate, usually distinct and in pentamerous symmetry; disc entire or with variable number of glands or wanting.

Male Flower: Stamens usually as many or twice as many as perianth- leaves or numerous or reduced to 1, free or monadelphous; anthers two celled with longitudinal or transverse dehiscence; intrastaminal disc usually present in multistaminate flowers; rudiments of ovary present or absent.

Female Flower: Naked or with a scaly perianth, staminodes present or absent; ovary tricarpellary, syncarpous, 2–4 chambered; ovules 1–2 and collateral in each chamber, pendulous, anatropous, with a ventral raphe; styles 3, free or basally fused, each often bifid; stigmas 3 or 6.

Floral Formulae:

Male flower : $\oplus\ \delta\ P_{(3-5}\ A_{1-\infty}\ G_0$

Female flower : $\oplus\ \varphi\ P_{3-5)}\ A_0\ \underline{G_{(3)}}$

Pollination: Cross pollination being the rule is attained through the agencies of wind and insects.

Fruit: A capsule (*schizocarp*) splitting into three one–seeded cocci that dehisce ventrally, rarely drupe or nut.

Seed: Endospermic, endosperm soft-fleshy and with a large central straight or bent embryo.

VEGETATIVE CHARACTERS

Habit: Herbs, shrubs or trees, often with milky juice, which is lightly acrid, narcotic or corrosive; sometimes fleshy and cactus-like.

Root: Tap-root.

Stem: Annual or perennial, erect or prostrate, fleshy, sometimes spiny.

Leaf: Mostly alternate, sometimes opposite or whorled, simple or variously compound, usually stipulate, sometimes reduced to various structures.

Economic Importance:

The family is of considerable importance for some of its commercial products—oils (castor oil, AMLA oil, tung oil etc.), rubber (*Hevea*) and food (cassava and tapioca, AMLA fruits). Many members of the family are grown domestically as ornamentals (poinsettia, crotons etc.) while a few are important species of pharmacopoeia.

Genus: **Ricinus**

The genus is monotypic, consisting of a single species *Ricinus communis* Linn., although hundred forms are known. All forms grow as annuals in the temperate zone, but some forms grow as perennials in warmer climates. The native home of Ricinus is probably tropical Africa and is found to be cultivated since time immemorial.

The characteristics of the genus can be ascribed to the monoecious habit of the plant with apetalous flowers (pistillate above and staminate below) on a somewhat panicled raceme. The stamens are branched. The fruit is a spiny capsule and the seeds contain a poisonous substance *ricin*, and yield the castor-oil of commerce. The seeds vary much in colour, size and composition giving rise to different varieties.

Ricinus communis Linn.

Hindi: ARAND *or* RERI *English*: Castor bean

Castor is a native of Africa. It is now grown throughout tropical and subtropical countries, particularly in the drier regions, as the plant can stand considerable drought but shows a strong aversion to water logging. It is grown from earliest times for its valuable oil, used in medicine, art, preparation of food, lubrication and illumination. Sometimes they are commonly grown as domestic ornamentals for their foliage.

India is the chief castor-oil producing country. It is generally grown in the deep red loams both sandy and clayey and on good light alluvial loam and even on rough gravelly uplands. Its distribution in India is confined to the dry areas of the country, in Hyderabad, Mysore and Madras, covering about $1\frac{1}{2}$ million acres.

BOTANICAL DESCRIPTION

Habit: Herbaceous annual which become small trees in the tropics with perennial habit.

Root: Tap-root.

Stem: Glabrous or rarely subspinose, erect, herbaceous above and woody below, branched, branching repeatedly from below the flowering clusters.

Leaf: Large, alternate, peltate, palmately-lobed and veined with 5—12 lobes, lobes dentate or serrate; petiole with conspicuous glands.

Inflorescence: In terminal racemes, somewhat paniculate or subpaniculate; monoecious, both sexes present on the same peduncle, the females being aggregated above and males below.

Flower: Unisexual, regular, apetalous, hypogynous, incomplete.

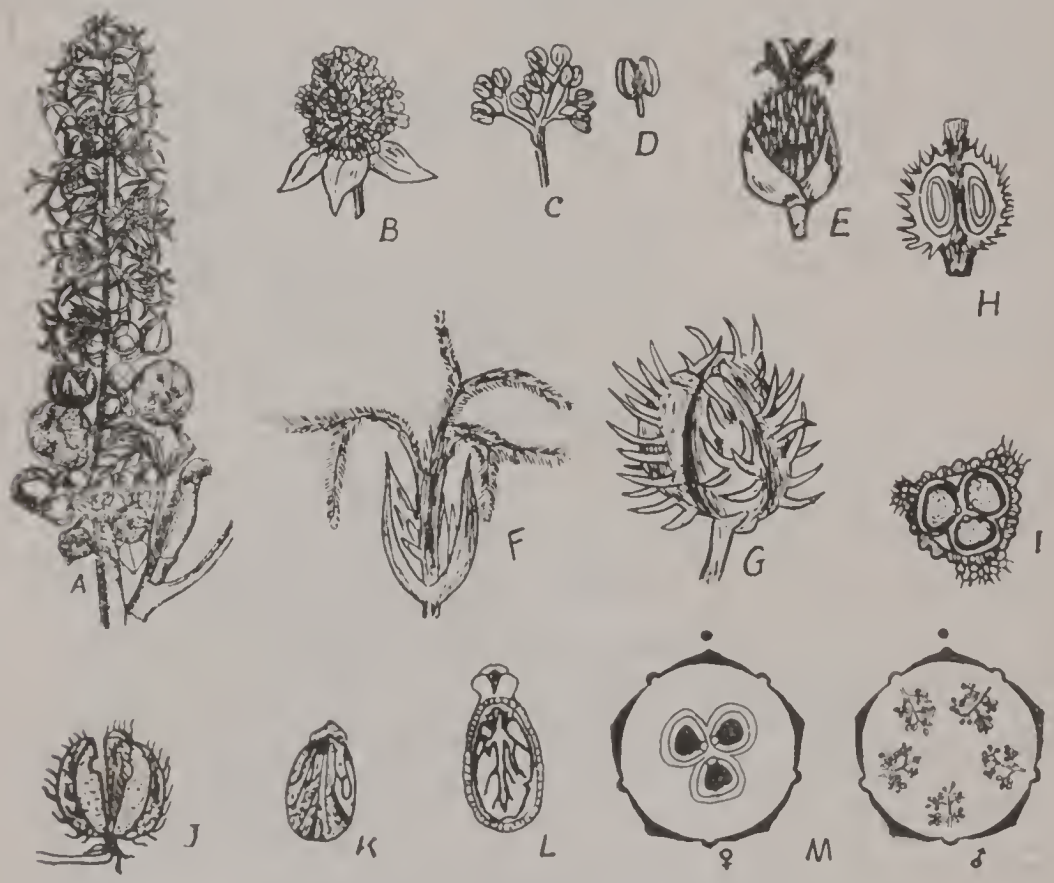

Fig 28—**CASTOR**

A. Inflorescence. **B.** Male flower. **C.** Branched stamens. **D.** Anther. **E, F.** Female flower. **G.** Fruit (capsule). **H.** Longitudinal section of ovary. **I.** Transverse section of ovary. **J.** Fruit dehiscing. **K.** Seed. **L.** Seed cut to show embryo. **M.** Floral diagrams.

Male flower: Short pedicelled, on upper part of raceme.

Perianth: Membranous, gamophyllous with 3–5 segments, valvate.

Androecium: Stamens numerous, arranged upon much branched filaments; anthers globose, 1–celled, divergent.

Gynoecium: Absent, with no rudimentary pistil.

Female flower: Situated below the staminate ones on the same peduncle (raceme) and longer pedicelled.

Perianth: Gamophyllous, with 3–5 segments, spathaceous, enclosing the ovary, splitting along one side, caducous.

Androecium: Absent with no staminodes.

Gynoecium: Carpels (3), syncarpous; ovary superior, spinose, trilocular, placentation axile, ovule one in each locule; styles 3, plumose.

Floral Formulae:

Male : $\oplus\ \delta\ P_{(3-5)}\ A\infty\ G_0$

Female : $\oplus\ \varphi\ P_{(3-5)}\ A_0\ \underline{G_{(3)}}$

Pollination: Cross-pollinated by anemophily.

Fruit: A schizocarpic capsule, generally covered with soft spinose processes and split explosively into three one–seeded cocci by ventral sutures.

Seed: Ovoid with a large aril; seed coat crustaceous, variously coloured and smooth; endosperm fleshy and oily; cotyledons broad, cordate or ovate.

SPECIAL REFERENCE

Sethi, R. L. (1931). Observations on the castor–oil plant (*Ricinus communis* Linn.) in the United Provinces. Agr. and Livestock in India. Vol. 1: Part I & III.

Genus: **Phyllanthus**

The genus Phyllanthus includes nearly 500 species mostly found in tropical regions. They are cultivated in greenhouses for their graceful flower and foliage or as hedges or some of them possess great economic use of their fruits which are variously utilized–as edibles, preserves and medicinal preparations or for extraction of valuable oils.

The species are mostly shrubs, some are herbs or trees and many do not contain latex. Leaves are small, entire, distichous

on the small lateral branches which then resemble pinnate leaves, the leaves leave conspicuous scars on the main branches after their shedding; several species have the branches flattened into leaf-like organs with flowers and rudimentary leaves on the margins. Flowers are axillary, unisexual, apetalous, monoecious or dioecious, in small clusters or solitary; perianth 5–6, free, orbicular, in two whorls of three each. Stamens usually 3 (may be 2–6 or more), monadelphous and present only in male flower; gynoecium is present only in female flower and having 3 united carpels, 3-chambered superior ovary, with 2 ovules in each chamber and axile placentation. Fruit–schizocarpic, opening in three cocci. Seed–endospermic.

Phyllanthus emblica Linn. (Indian gooseberry or AMLA):

AMLA is a short lovely tree with graceful feathery foliage and contains no latex. It is a native of India, Ceylon, Malaya etc. and commonly found in tropical forests and hill slopes upto an elevation of about 400 ft. It grows abundantly in Central and Southern India and is cultivated mainly for its fruits which are found, of the size of a large marble, green, becoming light yellow or brick-red when mature and are available during the winter months. The fruits have a thick acidulous kernel enclosing a seed and are quite uneatable when raw but used through either pickles or preserves which have great medicinal value. AMLA is reputed for its life prolonging properties. It is very rich in vitamin C. AMLA oil

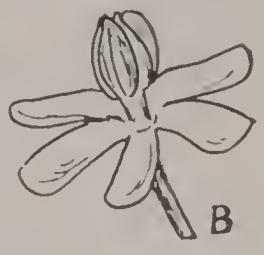

Fig. 29—**AMLA (P. emblica)**

A. The inflorescence. **B.** Male flower. **C.** Female flower. **D.** Branch bearing fruits and leaves.

is extracted by boiling the kernel in gingely oil and is a reputed hair oil.

P. distichus (Star gooseberry or NUREE or NURPHUL): A small ornamental tree, native of India, cultivated for its fruits which are taken as pickles or preserves or sometimes as a dessert.

CHAPTER VII

ORDER: GERANIALES

Rendle has classified the order Geraniales into 7 families. The members of the order are mostly herbaceous plants, sometimes woody with simple alternate (sometimes opposite) leaves. Flowers hermaphrodite, regular (rarely irregular), hypogynous, cyclic and pentamerous. Sepals imbricate in the bud, free, sometimes united at the base, often persistent. Petals imbricate in the bud, sometimes twisted, free, often fugacious. Stamens typically twice as many as sepals in two obdiplostemonous series (stamens in two whorls, outer opposite petals, inner opposite sepals) or sometimes the outer whorl missing (rarely numerous). Carpels united, often reduced to three. Ovules in the inner angle of each chamber, pendulous and anatropous; style often persistent in fruit. Seeds generally lack endosperm.

Family: LINACEAE (Linseed family)

Linaceae is a small family comprising 9 genera and about 200 species more than half of which belong to the genus Linum. These are usually mesophytes and of cosmopolitan distribution and primarily of temperate regions of both northern and southern hemispheres. The family is subdivided into two subfamilies—Eulineae and Hugoniea. Linum comes under the former.

The family is distinguished by the flowers which are generally pentamerous, regular, with the contorted corolla composed of distinct and usually clawed fugacious petals; stamens usually 5, opposite sepals and with shortly connate filaments and an outer whorl of 5 staminodes opposite petals; ovary superior, hypogynous and the fruit a septicidally dehiscent capsule.

Familiar Examples:

Cultivated flax or TISI or ALSI (*Linum usitatissimum*): garen ornamentals—*L. perenne* and *L. grandiflora*.

FLORAL CHARACTERS

Inflorescence: A dichasial cyme or cincinnus (sometimes appearing racemose).

Flower: Showy, bisexual, pedicellate, regular with pentamerous symmetry, hypogynous.

Calyx: Sepals 5, free, quincuncial or slightly basally connate, imbricate, persistent.

Corolla: Petals 5, free, regularly alternating with sepals, contorted in the bud, fugacious, often clawed.

Androecium: Stamens 5 (inner whorl) opposite sepals, alternate with small staminodes as tooth like projections (outer whorl) which are opposite petals; filaments of the stamens connate at the base, forming a ring on the outside of which there may be nectiferous glands; anthers 2-celled, introrse. dehiscing longitudinally.

Gynoecium: Carpels usually 5 (sometimes less), opposite the petals, syncarpous, forming five chambered ovary (rarely 3-4 chambered) or falsely 10-chambered due to the intrusion of a false septum from the dorsal suture in each locule; styles as many as ovary locules, free or united to the middle, filiform, each terminated by a capitate stigma; ovary superior with typically two pendulous anatropous ovules in the inner angle of each chamber; placentation axile.

Floral Formula: ⊕ ☿ K_5 C_5 A_{5+5} Staminodes $\underline{G_{(5)}}$

Pollination: By insects, which are attracted by coloured flowers and presence of nectary glands.

Fruit: A capsule or drupe with septicidal dehiscence and persistent calyx surrounding the base.

Seed: Compressed, shining with copious endosperm (often scanty) and usually with straight embryo embedded in it. The seeds are often rich in oil.

VEGETATIVE CHARACTERS

Habit: Mostly herbs, sometimes shrubs.

Germination: Epigeal. On germination the seeds become covered with mucilage, produced by the degeneration of cell walls in the outer layer of the seed coat.

Root: Tap-root, branched.

Stem: Erect, herbaceous or woody, fibrous inside, smooth surface, in most cases the stem branches only at the base in a corymbose fashion.

Leaf: Simple, alternate (rarely opposite), entire, small stipules present or absent, shortly stalked or sessile, linear or linear-lanceolate.

Economic Importance:

The family is important for the flax plant (*Linum usitatissimum*) that is widely cultivated for the long bast-fibres (from which linen cloth is made) and for the oily seeds (the source of linseed oil). The cakes obtained after the extraction of oil from the seed are utilised for cattle feeding or as manure.

Genus: **Linum**

The genus Linum is usually found in the temperate or subtropical regions of the world and more specially in the Mediterranean climate. It includes nearly 96 species out of which many are cultivated as field crops while others are grown as domestic garden ornamentals on account of their brilliantly coloured flowers. The most important species is flax or linseed.

The characters of the genus are typical to the family Linaceae to which it belongs. Flowers regular, hypogynous and arranged in a sympodial cincinni; calyx glabrous or pubescent. persistent; petals contorted, fugacious; stamens perfect, as many as petals often alternate with a similar number of teeth or aborted stamens all united to a hypogynous ring; styles 5. Fruit a capsule. roundish, splitting along the dissepiments Seeds with mucilaginous testa which swells on wetting.

Linum usitatissimum Linn.

Hindi: TISI, ALSI *English*: Linseed, flax

Flax is now, as in the past, the most important plant stalk fibre providing raw material for one of the most important textile industries. This plant is yielding linen since the pre-historic lake dwellers inhabited the Swiss lakes. Mummies placed in the Egyptian tombs four or five thousand years ago were bound up in linen cloth. It was grown on almost every European and American farm. In modern days the multifarious use of linen, as gunny bags, tows and scraped linen lint and a sort of tough and durable paper, unquestionably makes it superior to cotton as a fibre. The seeds (linseed) yield a valuable oil which is used in the manufacture of house paints and the oilcakes go to feed the cattle.

Flax grows in a much wider range of climate than cotton but is much more easily injured by drought or wet weather. It gives high grade fibres in the colder zone where it is grown parti-

cularly for the manufacture of linen. In the warm regions it gains importance as an important producer of oilseed.

The Indian production of linseed is very large and the exports from India form a large portion of the quantity imported into Europe. In India, more than three million acres of land are annually cultivated under this crop, of which, the major share goes to Bombay, M.P and Andhra. It is cultivated in most parts as a 'rabi' crop and is mainly confined to the black cotton soils (where it can grow without irrigation) and it can as well grow on low rain-fed areas and at sea levels or plains as distinct from hilly tracts.

BOTANICAL DESCRIPTION

Habit: Herbaceous annual (rarely perennial), growing upright to a height of 1–4 ft. Indian linseed is about $2\frac{1}{2}$ ft. in height.

Root: The root system is comparatively small, consisting of a main tap root which is slender and branched, possessing small, shallow and abundant lateral roots. Linseed has an intricate system of rooting and sends numerous fibrous roots or feeders occupying the soil very completely.

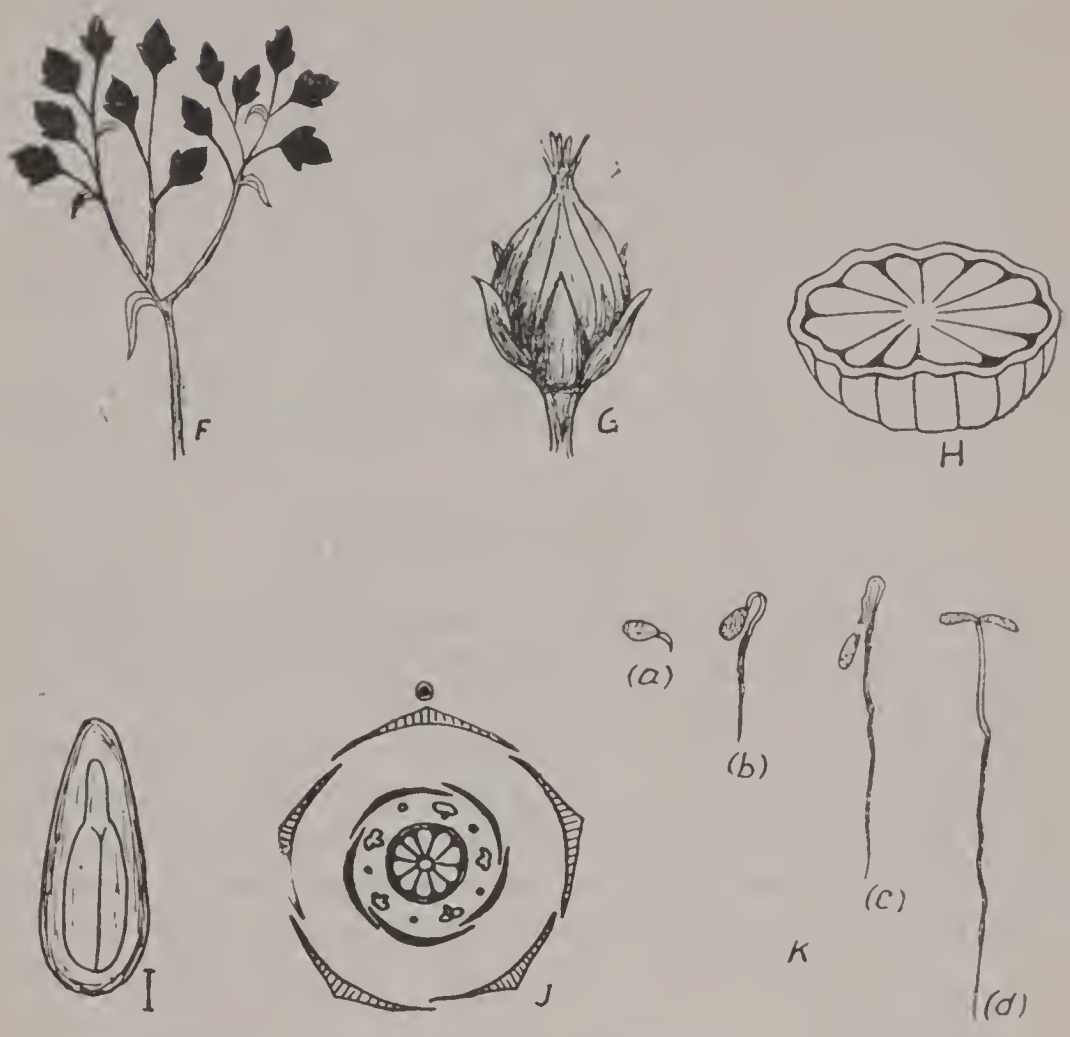

Fig. 30—**LINSEED**

A. Linseed plant. **B.** Inflorescence. **C.** Flower. **D.** Flower cut open **E.** Stamens and pistils with perianth removed. **F.** A branch bearing seed-balls. **G.** Capsule. **H.** Cross section of fruit. **I.** Longitudinal section of seed. **J.** Floral diagram. **K.** Stages of germination.

Stem: Erect and herbaceous, cylindrical, glabrous, corymbosely branched, branches arising from the base and ascending towards the apex; top branches in cymose manner; green, solid, fibrous inside. For the extraction of fibres, the stem is subjected to the process of "retting" or rotting, the object of which is to loosen the tissues of the stem so that the bast fibres can be easily freed from the cortex, wood and other parts of the stem.

The fibre varieties and seed (oil) varieties are morphologically different, the former being in general thin and tall-growing, non-tillering and sparingly branched while the latter are usually dwarf in habit, strongly tillered and much branched.

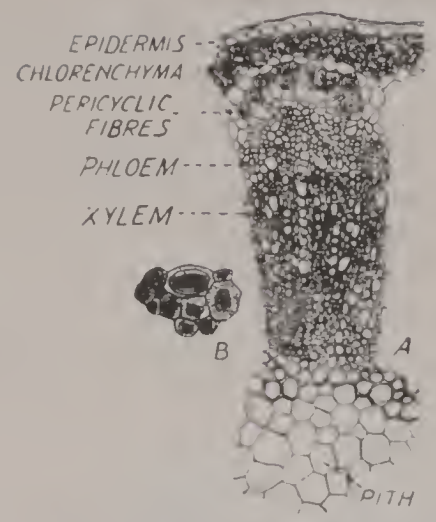

Fig. 31—**ANATOMY OF LINSEED STEM**

A. Transverse section of linseed stem. **B.** Transverse section of a group of fibres showing middle lamellae and concentric layers of secondary wall.

Anatomy of stem and fibre:

The internal arrangement of the structural element of stem shows the following:—

1. *Epidermis*: This is situated on the extreme periphery and consists of cuticularised well-marked epidermal cells but may be interrupted by the presence of stomata.
2. *Cortex*: This lies beneath the epidermis, consisting of parenchymatous cells, some of which contain chloroplastids.
3. *Bast fibres*: Next to the cortex is observed an interrupted ring of bast fibres, consisting of phloem parenchyma and phloem fibres in larger or smaller bundles and covering a fairly broad zone.

Fibre: In a full grown stem each individual fibre is a single elongated sclerenchyma cell about one inch in length with a very thick cell-wall (pure cellulose) and a small cell-cavity (lumen). Numerous cells are united in groups or bundles and these into long strands. The fibre cells are cylindrical, pointed at the ends.

4. *Cambium*: This separates the phloem from the xylem and is a narrow zone of delicate brick-shaped meristem.

5. *Xylem*: The xylem vessels are arranged in more or less radial bands and are separated by narrow medullary rays.
6. *Pith*: The centre of the axis is occupied by delicate parenchymatous cells, which break to form a hollow pith.

Leaf: Simple, small, narrow, entire, linear-lanceolate, apex acute or blunt; alternate, phyllotaxy usually 2/5, often irregular; exstipulate, subsessile, surface smooth; venation simple, multi-costate, convergent.

Inflorescence: In a sympodial cincinni (a monochasial cyme in which the successive lateral branches fall alternate on either side of the relatively main axis).

Flower: Pedicellate, pedicel long, slender and green; ebracteate, bisexual, complete, regular, blue coloured, hypogynous.

Calyx: Sepals 5, distinct, quincuncial, green; the two outer sepals are elliptical, acuminate, with entire membranous margins and the three inner sepals broader, acuminate with ciliate margins; all strongly 3-nerved, the middle nerve alone reaching the apex; smooth; aestivation imbricate; persistent.

Corolla: Petals 5, distinct, obovate, narrow at the base and much broad above (wedge-shaped); base white and the remaining portion blue; veined, veins many arising from the base; aestivation twisted; fugacious.

Androecium: Stamens (5), united at the base into a hypogynous ring and situated opposite sepals. Alternating with these fertile stamens there occurs an outer whorl of 5 glandular staminodes situated opposite petals. The filaments are long, filiform, expanded at the base, blue above; anthers basifixed, 2-celled, linear with longitudinal introrse dehiscence; pollens sometimes coloured.

Gynoecium: Carpels (5), syncarpous; ovary superior, 10-chambered due to the intrusion of a false septum in between each carpel; styles 5, free, blue; stigmas club-shaped and white; ovules two in each carpel or one in each of the ultimate cells, anatropous, pendulous; placentation axile.

Floral Formula: $\oplus\ \varnothing\ K_5\ C_{(5)}\ A_{5+5\ \text{staminodes}}\ \underline{G_{(5)}}$

Pollination: Homogamous; in these the visits of insects (attracted by colour and nectaries) may result in cross- or self-pollination according to the method of entrance. If insect

visits do not occur, self-pollination is effected by the bending inwards of the stamens and discharging the pollens on the stigmas. By some authorities (Hector, 1936) self-pollination is regarded as normal and cross-pollination to the extent of 40%.

Fruit: Capsule, commonly known as "seed-ball", mucronate in form, ten-chambered with one seed in each locule with persistent calyx at the base, dehiscing septicidally.

Seed: Compressed, flat, ellipsoid, smooth and shining, testa white to dark brown, with small amount of endosperm in which the straight embryo is embedded; cotyledons minute; oil content 35–47%. The epidermis of the seed coat is formed of cubical cells with very thick walls, consisting of a peculiar mucilaginous substance, which swells up into a slimy mass when put in water.

Germination: Epigeal, takes place readily when fresh seed is sown and the young plant sends its two elliptical cotyledons above ground.

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CHAPTER VIII

ORDER: RUTALES

The order Rutales has not been separated out from its closely allied order Geraniales by many authorities. Rendle has considered it to be a different order on the basis of the occurrence of a disc below the ovary and the very general presence of oil glands. The plants are usually woody. The order has been divided into 4 families (Rendle, 1925).

Family: RUTACEAE

The family comprises of trees, shrubs and rarely herbs with 1300 species, widely distributed in the temperate and tropical regions, but most numerous in Australia and South Africa. India has nearly 71 species.

The family Rutaceae circumscribes nearly 140 genera and simple or compound leaves dotted with sunken glands that secrete an aromatic volatile oil. Flowers bisexual, hypogynous, regular, outer stamens usually opposite the petals, with lobed ovary elevated on a disc, superior and multilocular.

Familiar Examples:

Lime or KHATTA NIMBOO (*Citrus aurantifolia*); sour orange or SANGTRA (*C. aurantium*); lemon (*C. limon*); shaddock or pummelo or CHAKOTRA (*C. maxima*); citron or NIMBOO (*C. medica*); elephant apple or KAITH BAEL (*Limonia acidissima* or *Feronia elephantum*).

FLORAL CHARACTERS

Inflorescence: Various, flowers usually borne in cymes.

Flower: Regular or sometimes slightly zygomorphic, bisexual (rarely unisexual), hypogynous, with an annular or cushion-like disc formation surrounding the ovary.

Calyx: Sepals 3–5, free or basally connate, inferior, imbricate.

Corolla: Petals 4-5, free (rarely fused), inferior, imbricate (rarely valvate).

Androecium: Stamens 3–10 or more, basically in two whorls, those of the outer ones usually opposite the petals (ob-

diplostemonous), all stamens attached at the base or rim of disc (occasionally some reduced to staminodes), filaments free or basally connate in several groups (polyadelphous), rarely epipetalous, usually straight and unequal; anthers bilocular, introrse with longitudinal dehiscence, sometimes with basal appendages.

Gynoecium: Carpels usually 4-5, often free below and united above (syncarpous); pistil usually 1; ovary superior, deeply lobed, typically 4-5 chambered, with usually 1-2 ovules in each chamber; ovules collateral or superposed; the styles as many as carpels and free or fused and seemingly one; stigma 1, capitate, sticky.

Floral Formula:

$\oplus \ \varnothing \ K_5 \ C_5 \ A_{5+5} \ \underline{G_{(5)}}$ with various modifications.

Pollination: Widely cross pollinated by entomophily. Colour of the flower, strong scent and honey secreting disc, attract insects for attaining cross-ferilization. Self-pollination is markedly prevented by protandry.

Fruit: Very various, generally capsule, drupe, berry or samara.

Seed: Many, endospermic or nonendospermic with a large straight or bent embryo.

VEGETATIVE CHARACTERS

Habit: Shrubs or trees (rarely herbs) with characteristic oil glands and often strong smelling; cultivated for their fruits.

Germination: Usually hypogeal.

Root: Tap-root, branched.

Stem: Erect, woody, branched and thorny.

Leaf: Alternate or opposite, simple or palmately or pinnately compound, generally smooth, dotted with sunken glands that secrete an aromatic volatile and scented oil, sometimes reduced to spines, exstipulate.

Economic Importance:

The family is of great horticultural importance for including the notable citrus fruits—orange, lime, citron, lemon, grapefruit, etc., and many other fruit trees like kumquat, BAEL (*Aegle*) KAETH (*Feronia*). It also includes many ornamentals —cork tree, hop tree, prickly ash, KAMNI (*Murraya exotica*),

common rue (*Ruta*), trifoliated orange (*Poncirus*) etc. Many have good medicinal values.

Genus: **Citrus**

The genus Citrus includes such important fruit trees as citron, lemon, orange and pummelo which belong strictly to the Old World, probably natives of tropical and sub-tropical Asia and the Malayan Archipelago. These are usually thorny shrubs or small trees with spines disposed singly in the leaf axils. The two prominent characters which distinguish the species belonging to Citrus from those of other plants are their aromatic flavour and total absence of root hairs. The leaves are glandular dotted, leathery, evergreen, unifoliate with winged petiole.

Classification of citrus fruits:

Classification of citrus fruits presents a very complicated problem. For reasons of simplicity and taste, the common cultivated citrus fruits of India cas be broadly classified into five groups:—

I. **Acid members:** Citron (*C. medica*); lemon (*C. limon* or *C. limonia*); rough lemon (*C. limetta*); lime or KHATTA NIMBOO or KAGZI NIMBOO (*C. aurantifolia*).

II. **Mandarins** or loose skinned oranges: Orange or Santra (*C. reticulata*); King orange (*C. nobilis*); Satsuma orange (*C. unshiu*).

III. **Pummelos and grape fruit:** Pummelo or CHAKOTRA (*C. maxima, C. decumana or C. grandis*); grape fruit (*C. unshiu*).

IV. **Oranges:** Sour orange or KHATTA SANTRA (*C. aurantium* or *C. vulgaris*); sweet orange or MALTA or MOSAMBI (*C. sinensis*).

V. **Others:** Calamondin or Panama orange (*C. microcarpa*).

We can frankly admit at the moment that there is no classification as yet universally accepted by the pomologists and botanists. There is a great deal of confusion regarding the English and vernacular names for different species and it is difficult to understand the species by their popular names unless they are fully described.

During recent years C. *trifoliata* (trifoliated orange) and *C. japonica* (kumquates) have been separated from the genus Citrus with their respective names as *Poncirus trifoliata* and *Fortunella japonica* and put under two separate genera due to their distinct peculiarities.

Citrus species Linn.

Hindi: CHAKOTRA, MOSAMBI, MALTA, SATHGUDI *or* CHINI GALGAL, NIMBOO, KHATTA, MITHA NIMBOO, SANTRA, NARANGI, HAZARA ETC.

English: Lime, lemon, citron, sweet orange, sour orange, pummelo, grape fruit etc.

Citrus fruits including orange, lemon, citron and others of less commercial importance, are the advance guard of tropical fruit supply. India is unquestionably the native home of lemon and citron but it seems likely that oranges grew originally in the hilly country and woodlands of the Indo-Chinese peninsula and from there went northwards to China and westward of India. All these happened probably 3000 years ago.

Hundreds of varieties of oranges are known to be cultivated in various parts of the world of which Mediterranean oranges are of good quality. They are confined within tropics and subtropics and can endure a few degrees of frost for a short period but lemon is the most tender of the cultivated citrus species and can barely stand even a short exposure to freezing temperature.

Oranges once regarded as luxuries, are now very common as a fresh dessert and also for preparing orange juice. Lemons have multifarious uses. They are used for lemonade, as flavouring for puddings and pie, as a bleaching agent and as a stain remover. Cull lemons are utilized for the production of lemon oil and the industry is practically entirely concentrated in Sicily.

About nine varieties of oranges and a number of different types of lemons are known to be cultivated in India. Oranges of a round, plump type of Khasia Hills, loose-skinned variety of Coorg and Nagpur, Light-skinned Malta type of the Deccan, and the Jamaica and Navel oranges are some of the types worth mentioning. Kaghuzee, Gora, Cheena Gora, Kamuralee Rungpore etc. grow in abundance in different parts of India.

BOTANICAL DESCRIPTION

Habit: These are evergreen small trees or shrubs, more or less spiny and cultivated for their edible fruits.

Root: The citrus roots do not possess root hairs and depend on mycorhizas for absorption of water from the soil. There is normally a large tap-root, but this does not appear to be essential and is often removed during trnsplantation of seeded plants.

Stem: Erect, woody, branched, with thorns, which are modified branches growing in the axils of leaves (sometimes absent).

Leaf: Thickly dotted with glands which secrete an essential scented volatile oil. These glands occur in the epidermal portion of practically every organ except the roots—appearing even in the embryo. The persistent leaves apparently simple but are really unifoliate compound, the blade being the terminal leaflet of a trifoliate, pinnately compound leaf. The leaf is borne on more or less winged or margined petioles, which are usually articulated with the blade and at their attachment to the twig. The joint between the winged petiole and the base of the blade is evidence of the compound nature of the leaf. The leaf margin may be entire, crenate or dentate with occasional marginal oil glands.

Inflorescence: Raceme, rarely solitary in the axils of the leaves or in small lateral or terminal cymes or panicles.

Flower: White or pinkish purple in bud, regular, complete, hermaphrodite.

Calyx: Sepals (3—5) usually (5), green, gamosepalous or free, calyx tube usually 3-5 lobed, gland dotted.

Corolla: Petals 4—8, usually 5, free, fleshy, white, strap-shaped, not clawed at the base, waxy, with oil glands, alternating with sepals, imbricate. Nectary glands are situated at the base of the corolla.

Androecium: Numerous (10—60, usually 20—40), polyadelphous, cohering towards the base in a few bundles; anthers dorsifixed, introrse with longitudinal dehiscence.

Gynoecium: Generally 4—5 or polycarpellary, syncarpous; ovary superior, multilocular, with a prominent usually deci-

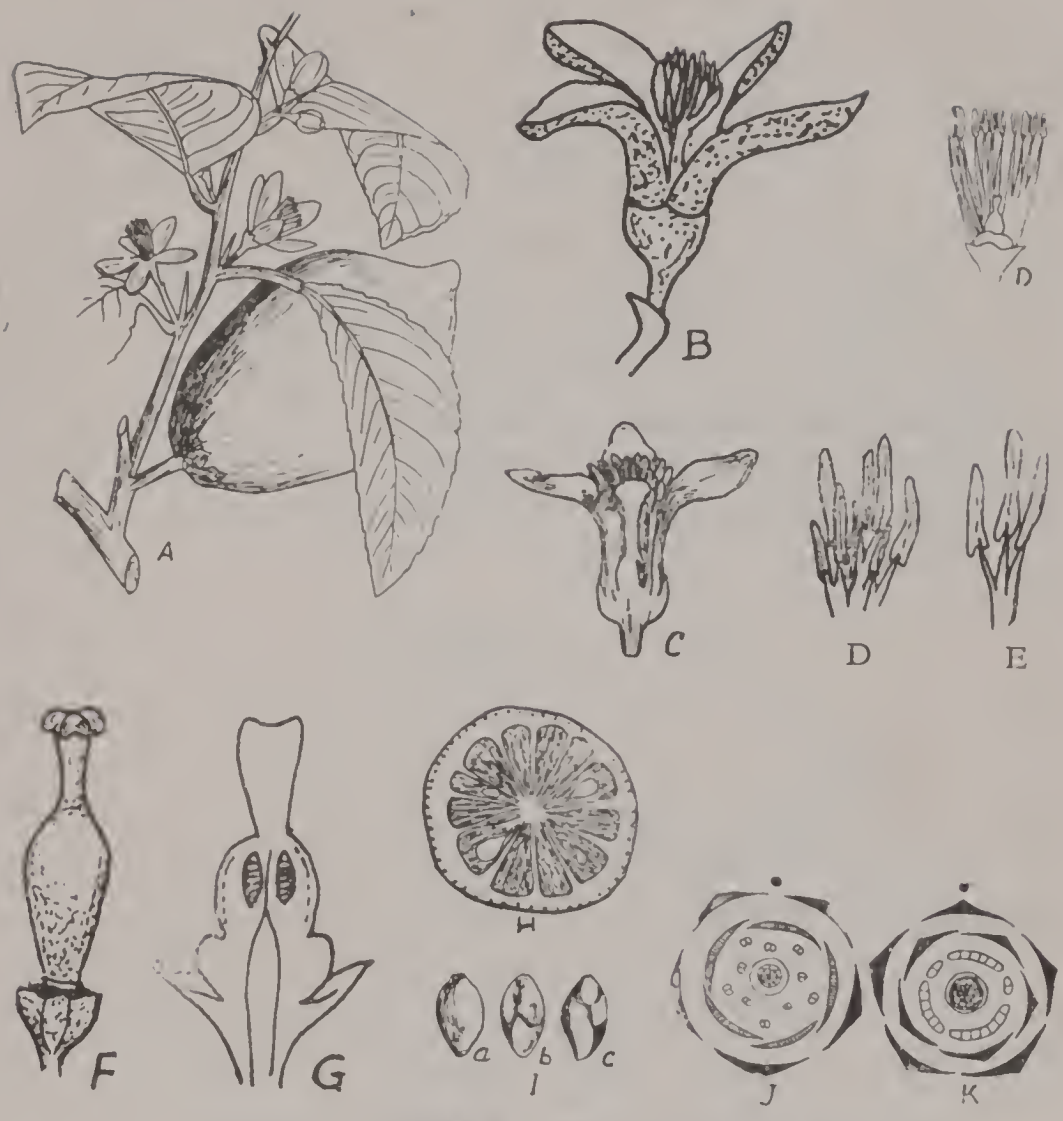

Fig. 32—**CITRUS Sp. (C. medica)**

A. Flowering and fruiting branch. **B.** Flower. **C.** Flower cut open. **D.** Cohesion of stamens (polyadelphous). **E.** Stamens shown separately. **F.** Pistil. **G.** Longitudinal section of pistil. **H.** Cross section of fruit. **I.** Embryos showing polyembryony. **J. K.** Floral diagrams.

duous style containing as many tubes as there are cells in the ovary; stigma capitate which secretes a white mucilaginous substance.

Floral Formula: $\oplus \ \varnothing \ K_{(5)} \ C_5 \ A_{10-\infty} \ \underline{G_{(5-\infty)}}$

Pollination: Entomophilous which is induced by the attractive corolla, strong scent and nectaries. In certain varieties fruit setting has been found to occur without pollination, such fruits are called **'parthenocarpic fruits'** and the phenomenon **'parthenocarpy'**. The species and varieties of citrus readily cross, and this fact renders the delimitation of their species exceedingly difficult.

Fruit: Hesperidium (berry), globose, oval or oblate-spheroid; the segments are filled with juicy pulp composed of stalked pulp-vesicles or sacs, with 1–8 seeds in each chamber.

Seed: Numerous; endosperm present or absent; oval or oblong in shape with a slippery feeling which is due to the mucilaginous nature of the outer membrane of the epidermis, which protects the seed from being crushed when the pulp is eaten by animals. The seeds contain a large embryo, which is straight or bent with flat planoconvex convolute or folded cotyledons. **Polyembryony** is frequent in citrus which is the occurrence of more than one embryo in a seed (normally a seed contains but one embryo). This introduces serious complications in breeding.

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CHAPTER IX

ORDER: SAPINDALES

The order Sapindales consists of usually woody plants (shrubs or trees) with numerous small flowers. The flowers are bisexual (sometimes unisexual); usually irregular or may be regular; generally 4-5 merous with reduction in number of carpels and frequently in androecium as well; androecium diplostemonous; gynoecium 2-3 carpellary, ovules with 2-integuments and 1-2 in each chamber with variable position, characteristically different from the allied orders. Fruit one seeded and of various types. Seed exalbuminous with a large embryo. The order has been divided by Rendle into 4 families.

Family: ANACARDIACEAE (Cashewnut family)

Anacardiaceae is a family of nearly 73 genera and 600 species, chiefly tropical but extending into Southern Europe and temperate Asia and Europe.

The family is characterized by the combination of intrastaminal disc, presence of resin ducts, unilocular ovary and drupe-like fruits.

Familiar Examples:

Mango or AM (*Mangifera indica*); cashewnut (*Anacardium occidentale*); pistachio (*Pistacia vera*); mombin (*Spondias sp*); varnish tree (*Toxicodendron vernicifera*); mastic tree (*Pistacia lentiscus*).

FLORAL CHARACTERS

Inflorescence: Terminal or axillary panicle with numerous small flowers.

Flower: Typically bisexual but often unisexual by reduction, usually regular and pentamerous with reduction in number of carpels.

Calyx: Sepals 3–5, basally connate and sometimes adnate to the ovary together with other floral parts, mostly imbricate.

Corolla: Petals 3–5 (sometimes absent), distinct or rarely basally connate, imbricate, usually hypogynous, a short hypanthium sometimes present.

Androecium: Stamens typically 10 in two whorls but the number of fertile stamens vary much in different genera; free or sometimes basally connate, inserted with the petals at the edge or base of an annular, intrastaminal disc; anthers 2–celled and dehiscing longitudinally.

Gynoecium: Pistil 1; ovary superior, usually 3-carpelled but functionally 1-carpelled and unilocular rarely multilocular, with one ovule in each cell but usually a single ovule is functional when multilocular; ovule anatropous and parietal or seemingly basal in unilocular ovary; styles 1–6 (usually single); stigmas generally as many as carpels.

Floral Formula: ⊕ ☿ or ♂ or ♀ $K_{(3-5)}$ or free C_{3-5} A_{5-10} $\underline{G_{(1-3)}}$

Pollination: Usually cross-pollinated by entomophily.

Fruit: Commonly a drupe with a resinous mesocarp.

Seed: Endosperm scanty or absent with a large curved embryo.

VEGETATIVE CHARACTERS

Habit: Trees or shrubs.

Germination: Usually hypogeal.

Root: Tap-root.

Stem: Woody, containing resinous passages in the bark which is a characteristic feature of this family.

Leaf: Alternate (rarely opposite), exstipulate, simple or compound.

Economic Importance:

The Anacardiaceae is a family of considerable economic importance. Because of the resinous juice, it yields medicinal substances, varnishes, resins and oils–varnish tree (*Toxicodendron vernicifera*), mastic tree (*Pistacia lentiscus*). It is more important for its edible fruits or nuts–mango, mombin, Kaffir plum, cashew nut, pistachio etc. A few are notable ornamentals (*Cotinus* and *Rhus*) while others yield a number

of commercial products, e.g., *Schinopsis* sp. yields tannic acid and *Rhus succedanea* yields vegetable wax.

Genus: **Mangifera**

The genus Mangifera comprises about 30 species and is mostly a native of tropical Asia. It includes the various kinds of mangoes both cultivated and wild. *Mangifera indica* (common mango) is the most widely cultivated species while *M. foetida, M. odorata* and *M. caesia* are the three other species cultivated in Malaya and Indonesia.

The characteristic features of the genus are—leaves alternate, petiolate, entire, coriaceous; flowers small, polygamous, in terminal panicles; calyx 4-5 partite; corolla 4-5—petalled, petals free or adnate to the disk, imbricate; stamens 1—5, rarely more, inserted just within the disk, in most species there is commonly only 1 fertile stamen, the remainder being more or less abortive or reduced to staminodes; ovary 1—celled, oblique; the style lateral. Fruit, a large fleshy drupe, with a compressed fibrous stone.

Mangifera indica Linn.

Hindi: AM *English*: Mango

Mango is believed to be indigenous in some of the moist evergreen forests of the Himalayan foot hills of eastern India and Western Ghats. According to Mukherjee (1953) it had its origin somewhere in the Indo-Burma region during the Eocene

A

B

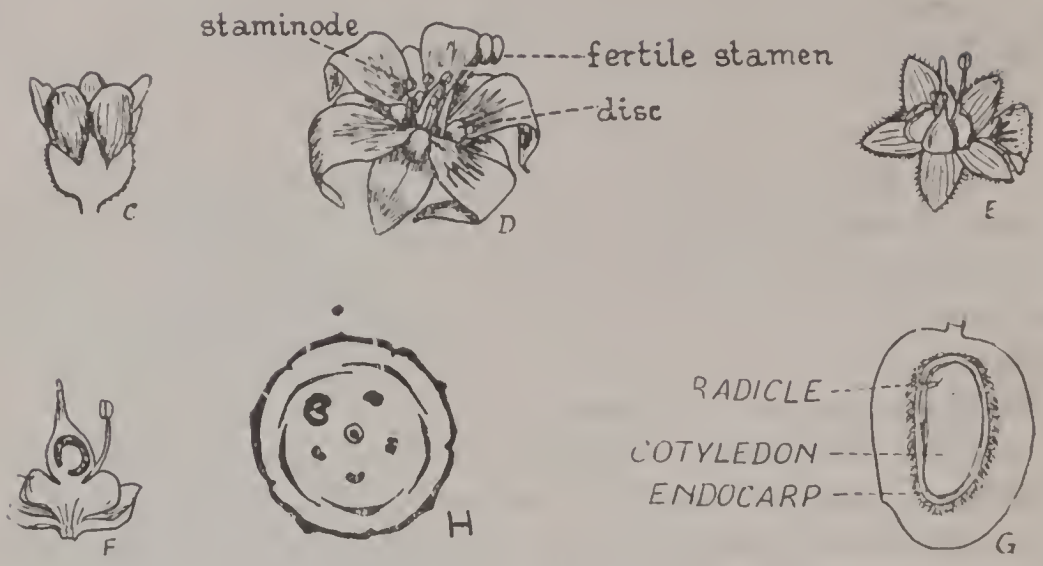

Fig. 33—**MANGO**

A. The mango tree. **B.** Inflorescence. **C.** Flower unopened. **D.** Bisexual flower (partial face view). **E.** Bisexual flower, corolla removed (front view). **F.** Longitudinal section of flower showing fertile stamen, ovary, intrastaminal disc and a part of perianth. **G.** Longitudinal section of a mango fruit. **H.** Floral diagram.

or an earlier period in the Cretaceous. It is a tropical tree and is cultivated for its high class edible fruits which are taker in various forms. The most common use is as dessert, other uses are as canned fruit or preserves in various forms. The fruits are very delicious in taste and rich in carbohydrates and vitamins A and C. The kernel of the seed also forms useful food for cattle. The timber is rather soft, rough-grained and not durable and hence used for packing cases and similar purposes. Propagation of mango is done variously—from seed, by transplantation and by grafting (inarching). It is grown since time immemorial and now cultured in many regions other than tropics.

Cultivation of mango in India dates back to remote past (more than 4000 years) and is mentioned in many old Sanskrit literatures. It played an important role in horticulture during the rule of Mohammedan emperors. The *Ain-i-Akbari* contains a long account of this "choicest fruit of Hindustan". Today it occupies about 60% of the total area under fruits in this country and thus is said to be the 'king of all fruits'. It blossoms during dry seasons and does not thrive above 5000 ft. Although it is remarkably tolerant to varied soils and climatic

conditions but a deep and well drained soil, with enough rain during wet season, a well marked dry season and less chance of frost during cold weather assure better return.

One of the greatest handicaps in the production of this fruit is its "alternate bearing habit." Trials are in progress through cultural means to have an even bearing.

BOTANICAL DESCRIPTION

Habit: A large evergreen tree with dense rounded crown of dark foliage, some may be of erect type.

Root: Tap-roots, penetrating to considerable depth with numerous branches sprawling out in all directions.

Stem: Woody with resinous bark.

Leaf: Alternate, oblong-lanceolate to elliptic, glabrous, leathery, shining, deep green, margins sometimes undulated, apex commonly acute; petiole long, swollen at the base.

Inflorescence: In stiff erect open bunches containing numerous flowers at the ends of branches as terminal panicles which are pubescent or rarely glabrate.

Flower: Small, yellowish-green or reddish, odorous, subsessile, staminate and hermaphrodite on the same panicle, polygamous.

Calyx: Sepals (4—5), gamosepalous, ovate-oblong, concave.

Corolla: Petals 4-5, twice as long as the sepals, ovate; imbricate, 3—5 ridged, the ridges orange, disk fleshy, 5-lobed.

Androecium: Stamens 5, one fertile and four reduced to non-functional staminodes of varying prominence; the intrastaminal disc is modified into a thick cushion developing between corolla and stamens; anthers purplish.

Gynoecium: Monocarpellary, ovary 1-celled, oblique, glabrous with a single lateral ovule; style lateral.

Floral Formula: $\oplus\ \delta$ or $\varsigma\ K_{(4-5)}\ C_{4-5}\ A_{1+4}\ \underline{G}_1$

Pollination: Usually entomophilous.

Fruit: A large drupe, usually compressed laterally, greenish, yellowish or reddish in colour with a compressed fibrous stone and a luscious mesocarp. The mango fruit has a more or less prominent beak and should be described as it lies on its side with its beak to the left; the beak is really the base of the style of the ovary. There are innumerable mango varieties in

India which are classified on the basis of shape and size of the fruit, size of stone, sweetness, smoothness of the skin etc.

Seed: A stone.

Germination: Hypogeal.

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CHAPTER X

Order: ROSALES

The order Rosales constitutes 17 families distributed among two suborders. These families are connected by transitional forms where two tendencies are distinctly visible: (a) from the regular to irregular condition of flower, and (b) from the hypogynous to epigynous condition of the receptacle.

Plants belonging to Rosales are of various habits and possess simple or compound leaves, with or without stipules. They are characterised by the flowers generally bisexual (rarely unisexual by abortion), cyclic, regular to zygomorphic, hypogynous to epigynous, typically pentamerous with frequent increase in the number of stamens and decrease in carpels. Stamens of many whorls free or sometimes united. Carpels united or free but styles generally distinct; ovules many (rarely few), anatropous, inserted in the ventral suture or on thick marginal or axile placentae; integuments typically two, sometimes single. Seeds large or small with or without endosperm.

Family: ROSACEAE

The family Rosaceae includes trees, herbs and shrubs of usually perennial habit having cosmopolitan distribution and abundantly found in E. Asia, N. America and also in Europe. It comprises of 100 genera with perhaps 2000 species. In India, quite a large number are being found in the Himalayan flora, rarely cultivated on plains (except rose) and possess many xerophytic characters.

The family is characterized by the usual presence of stipules, pentamerous perianth, stamens usually $10-\infty$ and carpels 1, 5 or ∞, presence of hypanthium in most genera (adnate to the ovary when the latter is inferior) and usual non-endospermic seeds.

Familiar Examples:

Rose or GULAB (*Rosa* sp.), raspberry (*Rubus idaeus*), strawberry (*Fragaria vesca*), peach or ARU (*Prunus persica*),

apricot or KHURMANI (*P. cerasus*), apple or SEB (*Pyrus malus*), pear or NASHPATI (*P. communis*), loquat (*Eriobotrya japonica*), medlar (*Mespilus*) *etc.*

FLORAL CHARACTERS

Inflorescence: Solitary or grouped in racemose or cymose manner with various types.

Flower: Generally bisexual, infrequently unisexual (the plant then dioecious); actinomorphic (very rarely zygomorphic); complete, with a pentamerous calyx and corolla; hypogynous (Prunus), perigynous (Rosa) or epigynous owing to the fusion of the carpels with calyx tube (Pyrus). The hollowed out torus or hypanthium is a characteristic feature of rosaceous flowers which may exhibit its various degrees of concavity:—(a) The hollow torus has a central protuberance (fleshy, conical, dome-shaped) on which the carpels are arranged (Fragaria). (b) The torus is slightly hollowed out but has no protuberance (Prunus). (c) The torus is hollowed out deeply and the carpels are attached to the inner wall (Rosa). (d) The torus is completely hollowed out and fused with the ovary forming a part of the fruit (flask-shaped) and completely enclosing the carpels (Pyrus).

Calyx: Sepals (5), occasionally (4), basally connate, sepaloid, greenish, often with an epicalyx (Fragaria) of outer and smaller leaves which represents the stipules of the sepals proper, adjacent ones having united in pairs (also called bracteoles). Calyx lobes usually imbricate. The sepals may be free or adnate to the ovary.

Corolla: Petals 5 or numerous in multiple of five (pentamerous), polypetalous arising from hypanthium rim (or absent in few); aestivation usually imbricate in the bud; rosaceous, petals large and showy; hypanthium often bearing honey secreting disc. The number of petals often increased in cultivated species as a result of the stamens being transformed into petals.

Androecium: Stamens usually numerous (sometimes definite and then usually 5 or 10); free and commonly arranged in several whorls of five stamens each; borne on the rim of the torus and perigynous around the gynoecium; bent inwards in the bud; anthers small, two celled, dehiscing longitudinally (rarely transversely or by pores). Stamens usually protandrous

Gynoecium: Either carpels 5 to many, apocarpous, ovary usually superior and carpels situated at the base of the hypanthium; or 1 to 5, syncarpous, ovary inferior and carpels adnate to the hypanthium. Styles commonly as many as carpels, free or connate, lateral or basal. Ovary unilocular when monocarpellary (or apocarpous) with 1 to 2 pendulous, ascending, anatropous ovules with basal placentation or when syncarpous composed of 2–5 locules and carpels with axile placentation and ovules few to several in each locule and terminated by as many styles (or style branches) or stigmas as carpels.

The nectiferous glandular disc lies between the stamens and carpels as cushion-shaped or ring-like structure and is easily accessible to visiting insects.

Usual Floral Formula: $\oplus\ \varsigma\ K_{(5)}\ C_5\ \infty\ A\infty\ G_{5-\infty}$ or $\overline{\underline{\quad}}_{(1-5)}$

Pollination: Mostly entomophilous, rarely anemophilous. Attraction for insects are nectaries, colour, smell and numerous pollens.

Fruit: Variable, a drupe, a pome, etaerios of drupes, achenes or follicles.

Seed: Exalbuminous, embryo small with planoconcave often fleshy cotyledons.

VEGETATIVE CHARACTERS

Habit: Herbs, shrubs or trees, sometimes climbers; often thorny and possess many xerophytic characters.

Root: Tap-root, branched.

Stem: Herbaceous, hard and woody, much branched. Some have characteristic vegetative reproduction by runners (strawberry) or suckers (raspberry).

Leaf: Alternate, simple or pinnately compound; stipulate, stipules often adnate to the petiole or caducous; leaf base conspicuous; spines may also occur on the rachis. In warmer climates the leaves are often leathery and evergreen, generally deciduous.

Classification of Important Cultivated Plants belonging to Rosaceae :

The family often is subdivided into several subfamilies or tribes, out of which 4 subfamilies are of considerable agricultural importance:–

I. **SPIRAEOIDEAE:** Carpels 12–1, usually 5–2, whorled, borne on a torus which is flat or slightly concave, never forming a convex carpophore or a deep cup, ovary with 2-many ovules in each; fruit a follicle or capsule (achene in one genus), usually dehisce; stamens on broad base, tapering upwards; stipules often absent.

GROUP: (1) **Spiraceae** (seeds not winged):

Genera: Spiraea (spiraea) and **Physocarpus** (ninebark) —are important ornamental shrubs.

Floral formula: $\oplus\ \heartsuit\ K_{(5)}\ C_5\ A_{10-\infty}\ \underline{G_5}$

GROUP: (2) **Quillajeae** (seeds winged).

Genus: Exochorda (pearlbush)—ornamental shrub.

II. **POMOIDEAE:** Carpels 5–2, united to inner wall of the deep cup shaped receptacle, usually syncarpous; ovary inferior; stamens 20 or more; fruit indehiscent, dry or fleshy—the axis is fleshy in fruit; stipules present.

Floral formula: $\oplus\ \heartsuit\ K_{(5)}\ C_5\ A_{20-\infty}\ \overline{G_{(5)}}$

GROUP: **Pomarieae.**

Genus: Pyrus*: is an important genus including a number of important edible fruit trees [*P. communis* and *P. persica* (Pear, NASHPATI); *P. malus* (apple, SEB)].

Genera: Eriobotrya* (*E. japonica* or loquat) and **Mespilus** (medlar) are also important for producing edible fruits.

Genera: Cotoneaster, Crataegus (hawthorn), **Photinea, Chaenomeles** (flowering quince), **Sorbus** (mountain ash) are notable as ornamental trees and shrubs.

III. **Rosoideae:** Carpels infinite or rarely one either on swollen receptacle as in Fragaria or at the bottom of the cup shaped torus as in Rosa; pistil distinct and free from hypanthium wall; fruits one seeded, indehiscent; plants shrubs or scramblers armed with prickles; leaves compound, pinnate, stipulate.

Floral Formula: $\oplus\ \heartsuit\ K_{(5)}\ C_5\ -\infty\ A\infty\ \underline{G\infty}$

GROUP: (1) **Kerricae:** Stipules distinct, axis not forming a part of the fruit; stamens tapering upwards from broad base; carpels few, whorled; stamens infinite.

* To be dealt in further details.

Genera: Rhodotypos (jetbead); **Kerria** (kerria); **Neviusia** (snow wreath)—are important ornamental trees and shrubs.

GROUP: (2) **Potentilleae:** torus cuplike enclosing carpels, carpels usually infinite in a head or rarely few and then stamens also few.

Genus: Rubus (loganberry)—flowers conspicuous, no epicalyx, honey secreted by a ring shaped nectary upon the hollowed axis just within the insertion of the stamens; flowers homogamous, visited by many insects including bees; fruits an aggregate of drupes. This consists of a number of important fruit trees:

R. idaeus (Raspberry)—trailing or climbing, multiples by suckers; *R. fruitcosus* (blackberry)—a hook climber, on reaching the soil gives adventitious roots and grow up into a new plant; *R. caesius* (sew berry)—fruits covered with bloom or wax like grapes; *R. occidentalis* (black cap raspberry or timble berry); *R. chamaemorus* (*cloudberry*).

Genus: Fragaria*—an edible fruit tree.

F. vesca (strawberry).

Genus: Potentilla (shrubby cinquefoils)—an ornamental shrub.

GROUP: (3) **Roseae:** torus cup like or tubular enclosing infinite carpels and fleshy in fruit.

Genus: Rosa* (Rose or GULAB): several species are cultivated in the gardens as ornamental plants.

IV. **PRUNOIDEAE**: Flowers regular, perigynous, torus deep, cupshaped, stamens more than ten, carpel 1 (rarely 2–5), ovary superior, ovules pendulous; style almost terminal; fruit a one-seeded drupe.

Floral formula: $\oplus\ \varnothing\ K_{(5)}\ C_5\ A_{10-60}\ \underline{G_1}$

GROUP: **Pruneae.**

Genus: Prunus*: consists of various cultivated fruits and a genus of great horticultural importance.

[*P. persica* (peach, ARU); *P. communis* (plum, ALUCHA); *P. domestica* , (prune); *P. amygdalus* (almond); *P. carasus* (cherry); *P. armenica* (apricot, KHURMANI); *P. avium* (sweet cherry) and *P. laurocerasus* (cherry laurel)].

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* To be dealt in further details.

Economic Importance :

The family Rosaceae is of considerable economic importance for the horticulturists as obvious from the huge assemblage of fruit producing members under the family and from which are obtained apple, pear, quince, cherry, plum, prune, peach, nectarine, apricot, almond, sloeberry, loquat, blackberry, raspberry, loganberry, strawberry and medlar. It also includes many important ornamental trees and shrubs commonly found in gardens, notably spiraea, ninebark, pearlbush, cotoneaster, firethorn, hawthorn, photinea, flowering quince, mountain ash, snow wreath, kerria, jetbead, Japanese cherry, rose, and shrubby cinquefoils. A few are of minor industrial importance for producing scents and perfumeries (e.g. *R. damascena*).

Genus: Pyrus

The genus Pyrus includes about 65 species, mainly found in the North Temperate climate. The genus is important for circumscribing such important fruit trees as apple (*P. malus*), pear (*P. communis*) and medlar (*P. germanica*) and several garden ornamentals.

These are trees or shrubs with alternate simple or compound leaves which are petioled and have small deciduous stipules. Flowers are regular, perfect, pentacyclic with numerous stamens; pistil single; carpels 5. syncarpous, ovary inferior, 5-locular, fused with the hypanthium, placentation axile, with 2 ovules in each carpel. The fruit is a pome (pseudocarp) where the receptacle becomes fleshy forming the greater portion of the fruit, enclosing the core which is made up of 5-bony, leathery or papery carpels. At the upper part of the pome is seen the *'eye'* of the fruit consisting of the so called calyx tube with remains of sepals, stamens and sometimes of styles.

Pyrus malus Linn.

(Malus sylvestris)

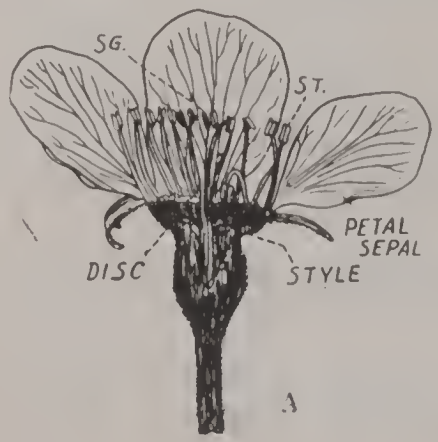
English: Apple

Hindi: SEB

On the Himalayas and other elevated regions of India grow many important temperate fruits notably apple apricot, pear, cherry, plum, peach, quince and walnut at an elevation of 3500–5000 ft. Owing to the perishable nature of most of them

and consequent necessity of quick transportation, they are grown to a limited extent mainly for local use, inspite of the fact that the country possesses a considerable amount of land well adapted for growing these commercial fruits. The estimated area under temperate fruits in the Indian Union is about 40,000 acres and approximate production is nearly 18,77000 maunds (Singh, 1957). A detail account of their cultivation has been presented by Hays (1953) and Singh (1957). Majority of them (except walnut) belong to Rosaceae. Of the various temperate fruits grown in India, apple is the most important and occupies nearly $\frac{3}{4}$ of the total area (Singh 1957). It requires a dry temperature when the blooms appear and a pretty long winter for best results. Such conditions prevail in Kashmir and Punjab where they are grown commercially. Absence of a long and cool winter and high temperature during summer make it impossible to grow on the plains.

The apple is probably native of the Caucasus region. They are eaten raw or cooked. Dried apples are used in Holland and Germany as a staple food. Surplus supplies of the fruit are converted into cider in the early autumn and later converted into vinegar through the process of fermentation which transforms the sugar to alcohol, and later to acetic acid by the agencies of various microorganisms. With the introduction of refrigeration system it has established its position in world commerce. Some states of the U.S.A. and Canada are big exporters of apples. In India apples come to perfection in the Kangra Valley, Kumaon districts and other hill stations on the Himalaya. The cultivation here is almost similar to that of Europe. The apple likes well-drained, clay-loam, and a high situation where frost is less likely. The Chotanagpur area shows a good potentiality for apple growing.



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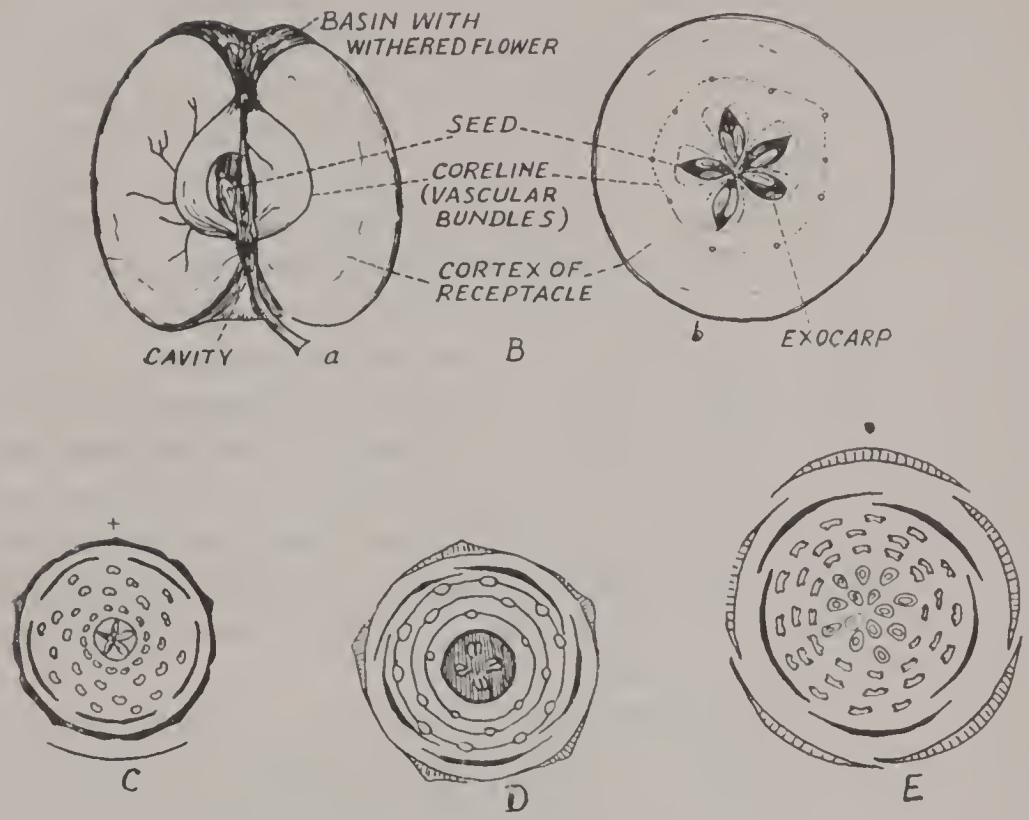

Fig. 34—**APPLE**

A. Longitudinally cut flower. **B.** Structure of the apple fruit—(a) Longitudinal section (b) Cross-section. **C.** Floral diagram of apple. **D.** Floral diagram of pear. **E.** Floral diagram of Rosaceae. Sg, Stigma; st, stamen.

BOTANICAL DESCRIPTION

Habit: Tree without any spines (unarmed).

Root: Tap-root, branched.

Stem: Erect, woody, branched.

Leaf: Simple, with a woolly petiole, ovate, smooth above and woolly beneath; stipulate, stipules drop early (caducous).

Inflorescence: Corymbose.

Flower: White or pink, bisexual, regular, epigynous.

Calyx: Sepals (5), gamosepalous, calyx tube bell shaped, five-lobed, lobes reflexed, calyx adnate to the ovary and becoming enlarged and fleshy in fruit, sepals persistent on the top of the fruit.

Corolla: Petals 5, free, orbicular, white, shortly clawed, superior.

Androecium: Stamens numerous (20 or more), free, in a number of whorls—outer whorl of 10 in five antisepalous

pairs, followed by a whorl of five antipetalous and a third whorl of 5-antisepalous stamens.

Gynoecium: Carpels (4-5), syncarpous, enclosed within and adnate to the calyx tube; styles 4-5, free to the base; stigma terminal, small; ovules two in each carpel.

Floral formula: $\oplus \; ♀ \; K_{(5)} \; C_5 \; A_{20-\infty} \; \underline{G_{(4-5)}}$

Pollination: The flowers are protogynous. Self-pollination is possible even without the visits of insects, but it is observed that many varieties are self-sterile, setting and the development of the fruit do not occur if the plants do not cross-fertilize. After the fertilization petals fall off, the stamens and styles wither and the rest of the flower develops into the pseudocarp termed as 'pome'.

According to Singh (1957), the majority of Indian apple varieties need inter-varietal cross-pollination for a good commercial crop production, although a number of them are self-fruitful.

Fruit: Pome, globose, fleshy, a pseudocarp consisting of large fleshy torus; having 2–5 parchment-like cells at the centre, each containing one or two seeds. Fruit indented at both ends and with a very short stalk.

The shape of the fruit varies widely in different varieties. It may be round, oblate, conical, ovate, elliptical etc. The depression around the stem is termed the *'cavity'*; at the opposite end from the cavity (i.e. at the flowering end) is the *'basin'*. The characters of the cavity and basin are used for the identification of varieties.

A median cross section and a longitudinal section of the matured fruit are shown in the provided figure. The pith of the receptacle is in reality the stem, which surrounds the five carpels radiating from the centre. Each carpel is composed of a parchment-like endocarp, a fleshy mesocarp and a fleshy epicarp. At the periphery of the pith the vascular bundles are situated (primarily ten in number) which forms the *core line*.

Common pear is another important cultivated fruit tree belonging to the same genus as apple which has similar botanical characters as decribed above.

Seed: Contained in a core, non-endospermic.

Pyrus Communis Linn. (Pear or NASHPATI)

Pear is probably indigenous in the North West Himalaya where it is now cultivated extensively but known from the earliest times to have been cultured in the South Europe and West Asia as well. It needs very similar cultural requirements as apples. It grows at elevations ranging from 2000–7000 ft. Therefore the temperatures are mostly mild in summer and cool-to-cold with heavy frosts and occasional snow falls in winter. It is a deep rooted crop and needs a moderately rich well drained soil not much shallow in depth.

The plants are strong upright trees, glabrous, young parts woolly and branchlets on young trees are often spinescent. Leaves on short spurs as well as on the axial growths; the pedicels and sometimes the young growth pubescent, but later all parts becoming smooth; leaves mostly broadly ovate, entire or obtusely serrate, acute apexed, of young plants lobed, hard in texture and bright green; petiole slender, nearly as long as leaf. Flowers 4–12 in umbel-like clusters on slender pedicels, white, appearing with the leaves; calyx persistent or rarely deciduous; stamens 15–20; styles 5, free. Fruits more or less turbinate but various, not intruded at the base, crowned with the persistent calyx and with gritty concretions in the flesh. In pear, most of the varieties are self-unfruitful or self-sterile and several have a pronounced capacity for setting fruit parthenocarpically.

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Genus: **Eriobotrya**

The genus Eriobotrya comprises of 12 species found abundantly in Warm Asia. They are small or large evergreen trees grown for their beautiful large foliage and also for their edible acid fruits. The distinguishing features of the genus are that the floral axis forms a deep cup with the inner wall, and to it the five syncarpous carpels are more or less completely united; carpels 2-ovuled; ovary inferior with 2–5 locules. The fruit is a pseudocarp consisting of the large fleshy torus surrounding the ripe ovaries the endocarp of which is thin membranous and surrounds the seeded chamber.

Plants evergreen; shrubs or trees; leaves simple, petioled or nearly sessile, entire or serrate with strong veins running straigrt to the teeth, leathery (adapted to xerophytic habits), stipulate with broad or lanceolate stipules. Flowers borne on a compound raceme as a terminal panicle, white, attractive with fragrance. Calyx united, five lobed, lobes small, erect or spreading, acute, persistent; calyx tube cone-shaped inverted cone-shaped or club-shaped. Petals 5, distinct, contorted or imbricate in bud, obovate or orbicular, usually slanting and notched with sinuate margins, the narrow base of the petal may be glabrous or woolly. Stamens many (usually 20) attached to the rim of the torus. Carpels (5), syncarpous, more or less united with torus; styles 2–5 connate and woolly below; ovary inferior, 2–5 loculed; 2 ovules in each locule which are basal or ascending; placentation axile (sometimes the seeds are surrounded by a cup-like organ—*cupuliform*). Fruit succulent or dry, rarely 1-2-celled berry or pome with persistent incurved calyx teeth and one or few seeds which are large, ovoid and cylindric, or flattened on one side, testa hard leathery and mucilaginous, cotyledons very thick.

Eriobotrya japonica Lindl.

Hindi: LOKAT

English: Loquat *or* Japanese medlar

Loquat is a small evergreen tree of about 25 ft. height with an ornamental crown, normally compact and dense. It is a hardy tree and can stand extremes of temperatures to a considerable extent but does not fruit in the tropics below 1,500 ft. It thrives well between 2,500 to 5000 ft. in the Himalayas of

Punjab and U. P. It averts the heat of tropics as much as frost of the temperate. Hence in its requirements it is strictly subtropical and is grown commercially in the Mediterranean regions. It thrives well on a variety of soils but a medium heavy soil with good drainage is considered to be better suited. The delicious loquat is a popular fruit of China and Japan of which it is a native.

BOTANICAL DESCRIPTION

Habit: Evergreen tree, with handsome foliage and large noble leaves and very hardy.

Root: Tap-root, branched, goes deep.

Stem: Woody, branched, erect.

Leaf: Simple, oval-oblong or obovate, apex acuminate, margin remotely serrate, thick and leathery, evergreen, stiff, woolly beneath, nerves in 12-15 pairs which are prominent beneath, base narrowed into a very short stout woolly petiole, stipulate—stipules are broad or lanceolate, acuminate and sub-persistent.

Inflorescence: Thick, stiff, woolly compound raceme, as a terminal panicle nearly 4—7 inches long.

Flower: White, nearly hidden in the rusty-woolly pubescence; bisexual, regular, with pentamerous perianth whorls; epicalyx absent and possesses fragrance.

Calyx: Sepals (5), gamosepalous, sepaloid, adnate to the ovary, clavate, calyx tube club-shaped.

Fig. 35—**LOQUAT**

A. Inflorescence. **B.** Flower cut open. **C.** Bunch bearing fruits and a few leaves.

Corolla: Petals 5, free, imbricate in bud, scented, white and showy.

Androecium: Stamens many, borne on the rim of the torus.

Gynoecium: Carpels (5), syncarpous, epigynous; ovary inferior, 2–5 locular; styles connate and woolly below with 2-ovules in each locule.

Floral Formula: $\oplus\ \mathfrak{P}\ K_{(5)}\ C_5\ A_\infty\ \underline{G_{(5)}}$

Pollination: Mostly entomophilous.

Fruit: Borne in clusters and resemble a very small pear. It is a succulent pseudocarp formed from the calyx tube, yellow, endocarp very thin, with few large seeds.

Seed: 2–5, angular, brown, smooth with agreeable acid flavour.

Propagation: The plants are usually propagated from seeds which should be sown immediately after maturity. Grafting is done for obtaining better varietes. Polyembryony often occurs in loquat and hence needs careful selection of seedlings before planting.

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Genus: **Fragaria**

The genus Fragaria consists of 10 species, mostly found in the Northern Hemisphere and in Chilli. They are usually low perennial herbs that appear stemless, with scaly rootstock or crown and rooting runners and are grown for their excellent fruits while a few species are for ornament. Leaves palmately trifoliate, stipulate and toothed, all from the crown. Flowers white or reddish, showy, in corymbose racemes on slender, leafless scapes; calyx united, deeply 5–lobed with 5 epicalyx; petals 5, distinct, obovate, elliptic or orbicular; stamens many, short, sometimes lacking; pistils many, apocarpous, borne on a swollen conical receptacle. Fruit is an aggregate of hard achenes and persistent on the fleshy receptacle which latter becomes edible; seeds pendulous.

The common cultivated species of Fragaria are: *F. chiloensis, F. virginiana, F. moschuta and F. vesca.*

Fragaria vesca Linn.

Hindi: STRAABERY · *English*: Alpine or Perpetual strawberry

The strawberry is a herbaceous perennial that naturally propagates itself by runners and is popular in gardens for its delicious fruits and the ease with which it can be cultivated. The fruits are juicy and pleasantly sweet and rose scented from which the name 'fragaria' is obtained. The soil required is well-drained rich loam. Both water-logging and drought are equally averted by the strawberry plants.

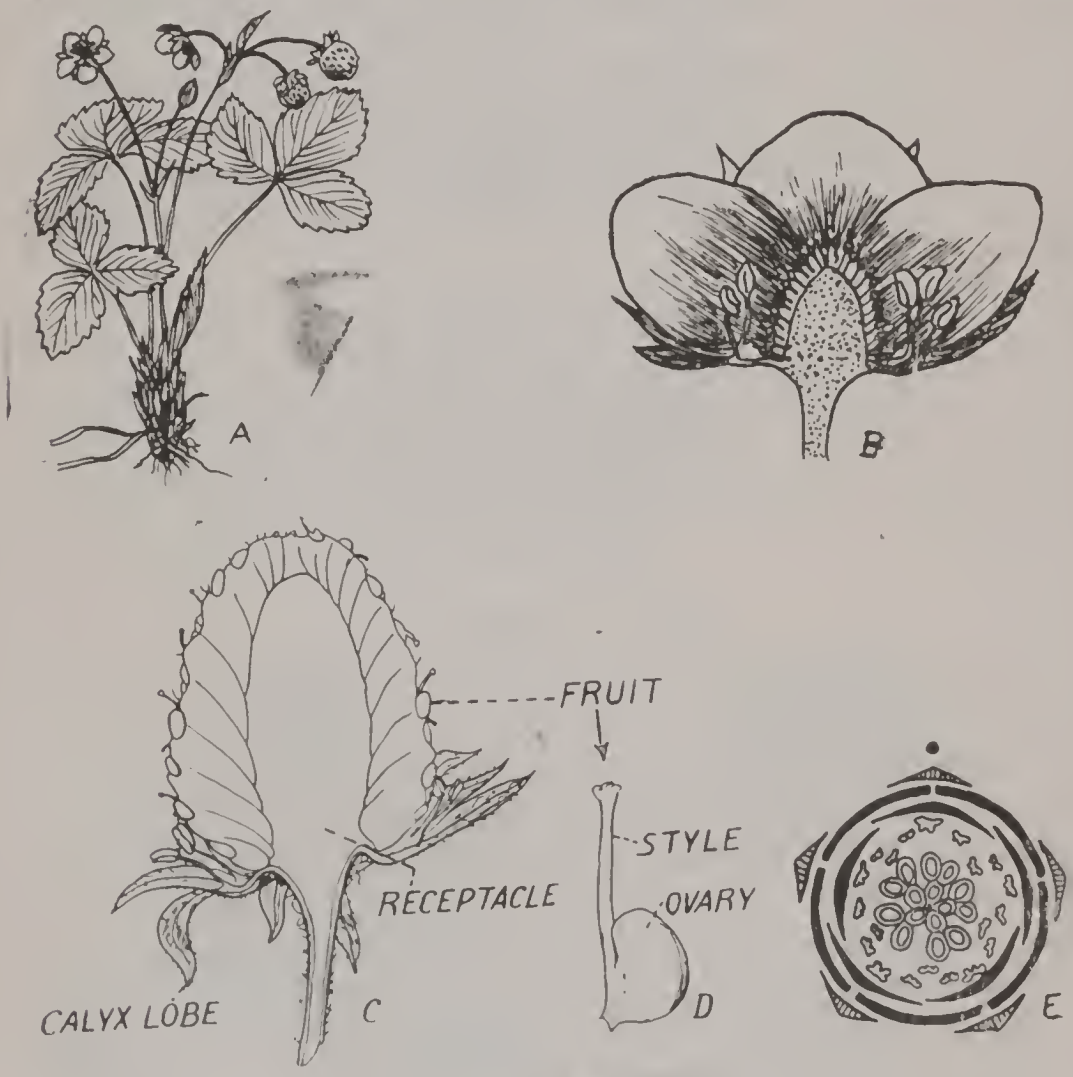

Fig. 36—**STRAWBERRY**

A. The plant. **B.** Longitudinal section of the flower. **C.** Longitudinal section of the aggregate of fruits. **D.** A single fruit (achene). **E.** Floral diagram.

In India strawberry is more common in the Himalayan flora. Nearly 200 acres produce the fruit commercially in and near the hills of Northern India, and about 60 acres at such hill stations like Mahabaleshwar in Bombay and Coonoor in the south (Hayes, 1953). It grows above 4000 ft. and when cultivated on lower elevations bears fruits of inferior quality and flavour. Due to the perishable nature of the fruit the cultivation of strawberry in India is limited by climatic conditions and the difficulty to transport them. It needs a well manured soil with shallow cultivation and frequent irrigation. The fruits are borne in spring and should not be picked until fully ripe.

BOTANICAL DESCRIPTION

Habit: Prostrate, perennial herbs producing long runners.

Root: Adventitious roots develop from stem nodes (runner) while the seed gives rise to branched tap-roots.

Stem: Weak, herbaceous, branched, trailing as runners and sparsely hairy. Vegetative propagation from stem is common.

Leaf: Pinnate compound, rachis bearing three sharp-toothed thin leaflets, stipulate, leaf base conspicuous.

Inflorescence: Cymose, small, forking, erect.

Flower: Hermaphrodite, complete, hypogynous, regular, small with the presence of epicalyx. If a vertical section of a strawberry flower is cut, the characteristic peculiar receptacle can be easily seen. It consists of a solid roundish or cone-shaped structure (central protuberance) round the base of which extends a flat rim. To the flattened rim is attached the corolla and the androecium while in the centrally raised part gynoecium is inserted.

Calyx: Sepals (5), gamosepalous, green, with the presence of epicalyx. The epicalyx constitutes a whorl of 5 sepal-like members alternating with the calyx which represent two united stipules belonging to the adjacent true sepals.

Corolla: Petals 5, free, attractive, imbricate in bud, apex rounded, entire margin and veinless.

Androecium: Stamens many, attached to the flat rim of the torus, anthers basifixed.

Gynoecium: Carpels numerous, apocarpous, inserted upon the central protuberance of the torus. Each carpel has a

lateral style; ovary superior, unilocular and contains a single ovule; placentation basal.

Floral formula: ⊕ ☿ $K_{(5)}$ C_5 A_∞ $\underline{G}$

Pollination: Flowers are protogynous and cross pollinated by entomophily. Attractive flowers, with nectaries and good number of pollens draw the insects for cross-pollination. In some cultivated varieties (common in America) the plants tend to become dioecious or polygamous. In such cases the flowers do not possess stamens and neither bear the fruits proper, nor do the receptacles of such pistillate flowers develop unless the pollen is brought from another flower. Hence in such cases there is a necessity for planting the kinds bearing staminate or bisexual flowers in proximity, in order to secure the fruit of such varieties.

Fruit: An etaerio of dry achenes on a fleshy receptacle. It is the receptacle or the terminal part of the flower-stalk which is the edible part of a strawberry, the true fruit (ripened gynoecium) being the achenes which is firm, small and usually hemispheric.

There are some peculiarities in the development of fruit. After fertilization, the flower bends down while the fruit ripens. During the ripening of the fruit, the gynoecium develops into the true fruit (composed of small one-seeded achenes) while the receptacle grows to a large size, becoming at the same time succulent. The succulent growth of the receptacle appears to depend on the fertilization of the ovules within the carpels. Should any of the carpels be injured and fertilization be prevented, the part of the receptacle on which such carpels are situated does not develop, and the result is a deformed strawberry. The achenes, which at first, are crowded together, become separated from each other by the growth of the receptacle.

Seed: Nonendospermic.

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Genus: **Rosa**

The genus Rosa includes various species of roses (nearly 150 species) cultivated widely in the gardens as ornamental plants, chiefly for its beautiful and attractive flowers, fruits and foliage. Under natural conditions it is commonly found in the North temperate climate. For industrial use, they are sometimes utilized in the manufacture of rose-water and scents.

Deciduous or sometimes evergreen; upright, less often climbing or creeping shrubs with usually prickly stems; generally propagated by stem cuttings; leaves alternate, odd-pinnate or rarely simple; stipulate, stipules adnate to the petiole. Flowers terminal, solitary or corymbose at the end of usually short branchlets; white, yellow or red; bracts rarely persistent; petals and sepals 5, rarely 4; calyx tube persistent, globose ovoid or pitcher-shaped; lobes leafy, imbricate in bud; stamens many, inserted on the disk, disk coating the whole of the calyx tube but its mouth by its thickened margin, silky; pistils, numerous rarely few inclosed in the receptacle; styles subterminal, free or connate above; stigma thickened; ovule 1, pendulous. The urn-shaped receptacle becomes fleshy and berry-like at maturity, containing several bony achenes, erroneously called seeds.

Rosa Indica

Hindi: GULAB *English*: Rose

The rose is held in high estimation for the fulness, colour and fragrance of their flowers. Fifty years ago India hardly possessed a rose worthy of its name. Some of the good races of rose from Europe of high reputation when introduced into India have shown poor adaptation bringing forth not very double flowers and frequently semi-double, very deficient in depth of colour and greatly wanting in the richness of the perfume. The cultivation of roses on the hills is attended with far more satisfactory results than on the plains with astonishing perfection. The rose is noted for not only for its sweet fragrance but for its attractive colours of various kinds and shades, white, pink, red, crimson, copper, fawn and purple are some of the colours commonly met with in several parts of India. The Bussora rose (*Rosa damascena*) is distinguished for its rich perfume, is common all over India and in some places cultivated extensively for the manufacture of 'atar'.

Rosa rubiginosa (pink rose), *Rosa banksiae* (white rose), *Rosa gigantea* (pink rose of climbing variety), *Damask perpetual* (delicate bluish colour), China rose etc. are some of the lovely common roses of India.

Fig. 37—**ROSE**

A. The plant. **B.** Longitudinal section of the flower. **C.** Floral diagrams of rose. **D.** Rose plants with flowers.

BOTANICAL DESCRIPTION

Habit: A branched prickly shrub, evergreen.

Root: Tap-root, branched.

Stem: Erect, branched, glabrous, prickly, prickles straight or curved with dilated bases.

Leaf: Petiolate; compound, imparipinnate; leaflets 7—11, nearly smooth, ovate, acute, teeth small, regular, leaflets smaller the further they are from the end leaflet; stipules very narrow, adnate, large—nearly to the apex and sheathing the base of leaf stalk and spreading.

Inflorescence: Large, solitary flowers (in certain varieties they are in clusters).

Flowers: Pedicellate, pedicel long and slender; complete, hermaphrodite, regular, perigynous, variously coloured; large, double, half double, rarely single.

Calyx: Sepals (5), gamosepalous, calyx tube urnshaped or tubular, 5—lobed, lobes narrowly lanceolate, thread-like, longer than the petals, tip often broad and toothed; odd sepal posterior, inferior.

Corolla: Petals 5 or multiples of 5, free, broad, rosaceous, large, coloured and conspicuous.

Androecium: Stamens numerous, free, inferior.

Gynoecium: Carpels many, apocarpous, situated at the bottom of the cup-shaped torus; pistil free from hypanthium wall; ovary superior; styles free, hardly protruding above the calyx mouth; stigma terminal; ovule solitary, basal.

Floral Formula: $\oplus\ \varnothing\ K_{(5)}\ C_5\ \infty\ A\infty\ \underline{G\infty}$

Fruit: Bright, red, pear-shaped formed by the succulent calyx tube, crowned by the persistent calyx lobes, enclosing several hairy achenes.

Propagation: Usually propagated asexually.

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Genus: **Prunus**

Prunus is one of the most interesting of all genera and includes such important orchard fruits as peaches, plums, cherries, apricots and almonds. It is also prolific of ornamental

subjects, as double-flowered, variegated leaved, coloured leaved and weeping forms. It comprises nearly 85 species the majority of which are North Temperate, a few Tropical.

Most of the species are hardy woody plants—shrubs or trees, deciduous and unarmed, with simple alternate leaves usually serrate and more or less gland bearing. The flowers are white or pink; either solitary or in clusters—fascicled, corymbose or racemed; perfect; perigynous, receptacle has the form of a hollow cup, around the edge of which are arranged the five sepals (gamosepalous, 5-lobed, calyx tube various) and five petals and 15-20 stamens. Carpel 1; style terminal; ovary superior, placed at the bottom of the hollow receptacle, unilocular; ovules 2 collateral and pendulous. After fertilization the receptacle soon withers and falls off, carrying all the floral parts with it. The carpel continues to grow and eventually develops into a drupe.

Prunus Persica Sieb. and Zucc.

(Amygdalus persica Linn. *or* Persica vulgaris Mill.)

Hindi: ARU *English*: Peach

The peach is a widely cultivated fruit tree for home and market and also grown in gardens as an ornamental. In India, it is generally propagated by budding on seedling peach rootstock. Fresh seeds do not germinate easily and are generally sown in October which germinate in the following spring. Planting is done in January or February and budding is performed in April and May or in September (Hayes, 1953; Singh, 1957). Amongst the various temperate fruits, peach probably stands the warmest climate with a temperature variation from freezing to 100°F and in India it thrives best on an altitude of 4,500–6,000 ft, with a rainfall of 8″–12″ mainly in winter. Hence its cultivation here is, to a limited extent on the plains as well as in the submontane areas and in the hills. It comes to perfection in Peshawar and Quetta (previously in British India) and at other places where the tree gets a thorough winter rest. It can also grow fairly well on the hilly tracts of western U.P., Bangalore and Mahabaleshwar. It thrives best on a deep, sandy, well drained soil but can not stand heavy damp soils.

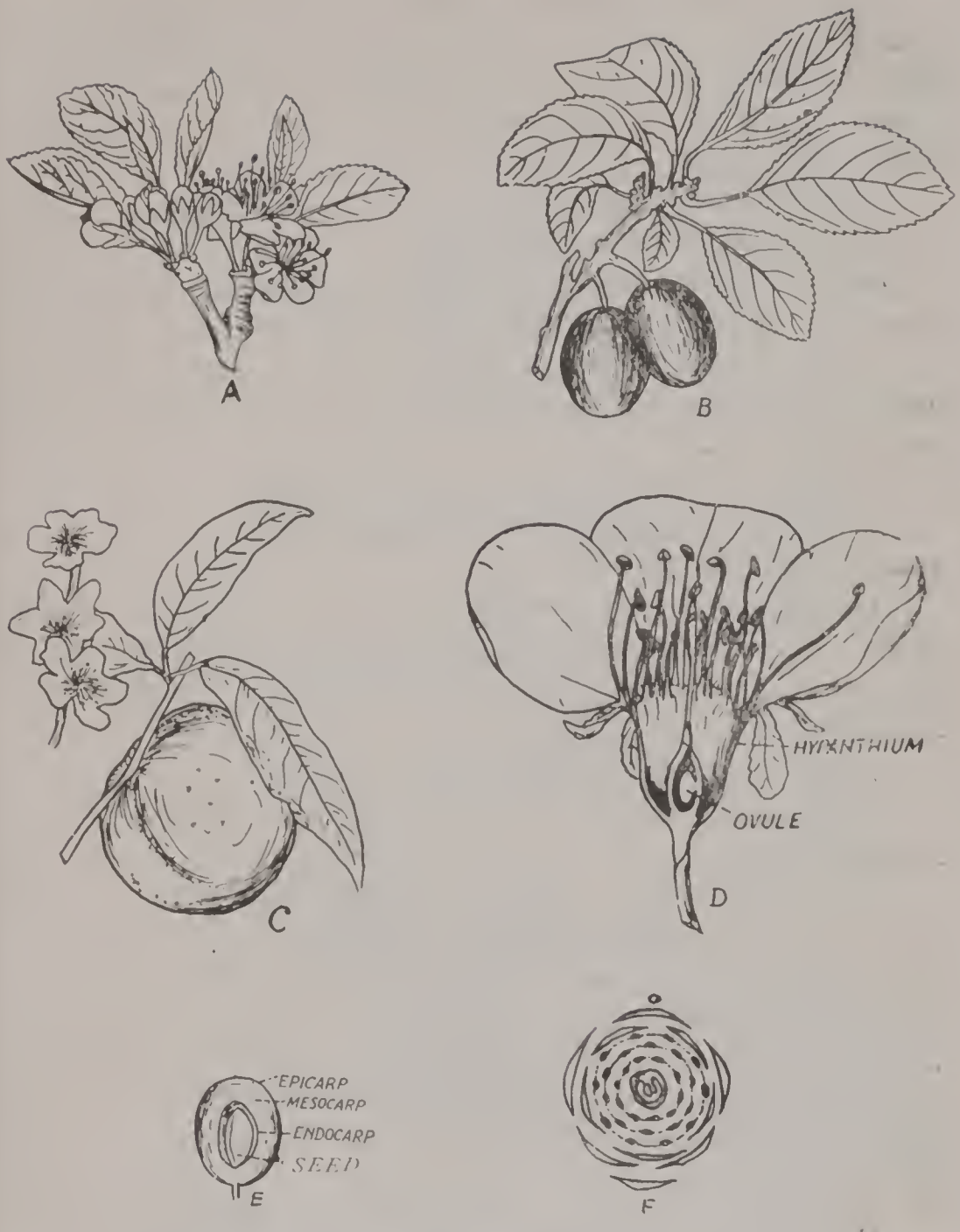

Fig 38—**PEACH**

A, B. The flowering and fruiting stalk of peach. **C.** The same of foreign variety. **D.** Longitudinal section of cherry flower (*P. cerasus*). **E.** Fruit longitudinally cut. **F.** Floral diagram of Prunus.

BOTANICAL DESCRIPTION

Habit: An unarmed, deciduous, glabrous shrub or small tree. Blooming occurs in spring.

Root: Tap-root, branched.

Stem: Erect, branched, woody.

Leaf: Simple, broad-lanceolate or oblong-lanceolate coarsely serrate, acuminate, usually hairy on the midrib beneath when young; petiolate, petiole usually provided with a pair of glands at the base, conduplicate in bud; stipules subulate fimbriate.

Inflorescence: Flowers solitary or in small clusters, crowded towards the end of branches.

Flower: Pink, sessile or shortly pedicelled, regular, bisexual, perigynous, appearing before the coming of new leaves.

Calyx: Sepals (5), gamosepalous, calyx tube campanulate, limb 5-lobed, more or less pubescent on outside, inferior, falling very early.

Corolla: Petals 5, free, obovate, inferior.

Androecium: Stamens 15–60, perigynous, inserted at the mouth of the calyx-tube.

Gynoecium: Carpel 1; ovary superior, situated at the base of the cup shaped torus but the ovary wall is not fused with the thalamus; style terminal, ovary and style hairy; ovules 2, pendulous.

Floral formula: $\oplus\ \varnothing\ K_{(5)}\ C_5\ A_\infty\ \underline{G_1}$

Pollination: Except a very few, all the varieties of peach are self-fruitful.

Fruit and Seed: A drupe, soft, fleshy pubescent at maturity, enclosing a hard furrowed deep-pitted one seeded very hard stone. The fruit consists of three distinct layers of tissues of different textures: (a) an inner hard bony layer next the seed termed as 'stone' of the fruit or endocarp, consisting of sclerenchymatous cells; (b) a soft parenchymatous layer—the "flesh" or mesocarp—with sweet cell sap; and (c) an outer thin skin or epicarp.

During the maturity of the fruit, the epicarp begins to harden (*'stoning period'*) with the increase in diameter by the thickening of the mesocarp.

Propagation: Plants are propagated both sexually and asexually.

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LEGUMINOSAE (Pea family)

Leguminosae is the third largest family of flowering plants with 600 genera and perhaps 13,000 species out of which 1,083 species have so far been identified in India. They are cosmopolitan in distribution. The subfamilies Mimosoideae and Caesalpinioideae are mostly tropical and Papilionatae (will be specially studied later) is largely temperate. Living in every soil and climate they show great variety in habits, from aquatics to xerophytes and from climbers to trees.

The family Leguminosae ranks second in importance next to Graminae and provides one of the essential constituents of food—*protein* through many of its species, broadly grouped under "pulses". Apart from its innumerable economic and non-economic uses, the agricultural importance of one of its subfamily Papilionatae for increasing the soil fertility is paramount. This is due to the nodule bearing character of its roots which contain nitrogen fixing microorganisms (*B. radicicola*). These microorganisms through a process of '*symbiosis*' enable the plant to make use of the atmospheric nitrogen which is stored up as nitrogenous materials in its tissues and later transferred to the soil by the natural process of decay of the plant-remains or by ploughing down the plant as 'green-manure'. These leguminous crops have great value on poor soils and must be included in the crop rotation.

The characteristic features of the family Leguminosae are the possession of lateral, slightly perigynous flowers and a monocarpellary pistil with unilocular superior ovary having marginal placentae which develops into a legume or pod. The leaves are usually compound and stipulate and the roots generally bear tubercles.

Familiar Examples :

Pulses: gram or CHANA (*Cicer arietinum*); pigeon pea (*Cajanus indicus* or *C. cajan*); pea or MATTAR (*Pisum sativum*); green gram or MUNG (*Phaseolus aureus* or *P. radiatus*); black gram or URD (*P. mungo*) etc. Vegetables: country bean or SEM (*Dolichos lablab*); cow pea or LOBIA (*Vigna sinensis*) etc. Timber trees: Indian red wood or SHISHAM (*Dalbergia sissoo, D. latifolia*). Oil yielder: groundnut or CHINIA BADAM or MOONGPHALI (*Arachis hypogaea*). Fibre crops: sunnhemp or SANAI (*Cro-*

talaria juncea) Dyes: indigo or NEEL (*Indigofera tinctoria*). Gums: wattles or BABUL (*Acacia*). KATHA: used with bettle (*Acacia catechu*). Natural fertilizers: sunnhemp, DHAINCHA (*Sesbania cannabina*). Fodder and forage plants: Lucerne or MAINA (*Medicago sativa*), clover (*Trifolium*), lupine (*Lupinus),* vetch or BAKLA (*Vicia*) alfalfa (*Medicago),* soybean (*Glycine),* sweet clover (*Melilotus*) etc. Ornamentals: Wisteria, butterfly pea (*Clitoria ternatea),* sensitive plant or LAJWANTI (*Mimosa pudica*) and many others with economical and non-economical values.

FLORAL CHARACTERS

Inflorescence: Apparently always racemose (indefinite type), but with many varieties; simple raceme is very common; panicles, spikes or dorsiventral racemes are also found.

Flowers: Bisexual, generally zygomorphic (sometimes actinomorphic), complete, slightly perigynous (the thalamus is generally hollowed out to form a small cup).

Calyx: Sepals usually (5), sometimes (4), inferior, gamosepalous and 5-lobed with the odd one (oldest sepal) anterior, generally more or less united, with imbricate or valvate aestivation, the latter especially in regular flowers.

Corolla: Petals usually 5, sometimes 4, polypetalous, or in regular flowers more or less united, equl in number and alternating with the sepals; corolla generally markedly zygomorphic; aestivation valvate or variously imbricated, ascending or descending. In many cases (Papilionatae) it is regular to a high degree, having a large posterior petal (standard), two lateral (wings) and two anterior more or less joined (keel).

Androecium: Stamens usually 10 or numerous, sometimes less than 10 by abortion, free or united into a tube and the union (cohesion) may be monadelphous or diadelphous [(9)+1] by the separation of the posterior stamen so as to leave a slit in the tube, only covered loosely by this stamen. Many variations are found. In cases where a keel is present, the stamens are enclosed in it. Anthers 2-celled, dehiscing by longitudinal slits or infrequently by pores, sometimes with an apical deciduous gland.

Gynoecium: Pistil 1, with its ventral side directly posterior; style and stigma 1, the long style with terminal stigma surmounts an unilocular, monocarpellary, superior ovary con-

taining generally 2 to many ovules arranged in two alternating rows (parietal placentation) along the ventral suture so as to stand on a single, placenta; ovules anatropous or amphitropous, obliquely ascending or pendulous or sometimes campylotropous.

Classification into Subfamilies :

The Leguminosae is divided into three subfamilies, treated by many taxonomists as separate families, *Mimosoideae, Caesalpinioideae* and *Papilionatae*—which appear to be entirely unrelated due to their variations in the arrangement and form of perianth segments, especially of the corolla and the number and cohesion of the stamens but the main coordinating characteristic is afforded by the pistil. The pistil, in all, is monocarpellary whose ventral suture is posterior; ovary unilocular with simple style and stigma and develops into a pod or legume with seeds arranged in one or two rows along the ventral suture and the fruit dehisce along both sutures at maturity.

I. **Mimosoideae :** Flowers actinomorphic; petals valvate, or imbricate; stamens more than 10 or twice as many as petals.

II. **Caesalpinioideae :** Flowers zygomorphic; petals imbricate-ascending; sepals in bud quite undivided (or tubular) or nearly polysepalous.

III. **Papilionatae :** Flowers zygomorphic and typically papilionaceous; petals imbricate—descending; calyx generally gamosepalous tending to become bilabiate with imbricate—ascending aestivation; stamens monadelphous or diadelphous or nearly free.

Number and cohesion of stamens, presence or absence of glands in petals, kind and stipulate behaviour of leaves and kinds of fruits, form the major line of further divisions of three subfamilies.

Floral formulae:

1. *Mimosoideae* : $\oplus\ \varnothing\ K_{(5)\text{ or }(4)}\ C_{5\text{ or }(5)\text{ or }4}\ A_{\infty}\ \underline{G_1}$
2. *Caesalpinioideae* : $\dagger\ \varnothing\ K_{(5)\text{ or }5}\ C_5\ A_{10}\ \underline{G_1}$
3. *Papilionatae* : $\dagger\ \varnothing\ K_{(5)}\ C_{1+2+(2)}\ A_{(9)+1\text{ or }(10)}\ \underline{G_1}$

Pollination: Allogamous by entomophily or autogamous.

Fruit: A legume or pod, containing one to many seeds and dehiscing by both dorsal and ventral sutures. In some, the

pod is constricted between the seeds, forming a *'lomentum'* which breaks up into indehiscing one-seeded portions. The pods frequently open explosively, the valves twisting up spirally, which help in seed dispersal. Among the other methods of seed dispersal which need special mention are: dispersal by the wind in case of winged, inflated pods or specially adapted seeds and by animals in the case of fleshy pods containing seeds with a hard testa. In some they are inflated.

Seed: With a leathery testa, on a short elongated funicle which often forms a more or less fleshy aril (an extra coat to the seed). It is usually exalbuminous or endosperm sparsely developed, often rich in starch and proteids which are reserved in the two large flat, fleshy cotyledons which form a part of embryo with a generally superior or ventrally placed radicle.

VEGETATIVE CHARACTERS

Habit: Herbs, shrubs, trees, water plants, xerophytes, climbers and many other forms.

Germination: Most members of the family show epigeal germination (hypogeal not rare, e.g. gram) and the cotyledons are pushed upwards by the rapid elongation of the hypocotyl, and function as the first green foliage leaves. A number of other interesting exceptional forms of germination are noticed in other cases.

Root: Normally they possess the tap root system and the roots of many species exhibit peculiar *'tubercles'* which are metamorphosed lateral roots containing peculiar bacterial organisms (*Rhizobium sp.*). With the aid of these microorganisms they are able to enlock a considerable quantity of the atmospheric nitrogen in their tissues which can be utilized in enriching the soil with nitrogen that is easily available to other plants.

Stem: Commonly erect, many are climbers by means of leaf-tendrils or stem-tendrils or by twining. Creeping stems root at the nodes (adventitious roots). Thorns are common which are usually modified branches or stipules. The stems of erect tropical species often branch so that the branches run parallel and erect, and bear crowns of leaves at the top. The stems of many lianes are peculiarly shaped, often flat, or corrugated in various ways, owing to peculiar growth in thickness.

Leaf: Usually pinnately compound (rarely simple), alternate, stipulate; many have very small or scaly leaves; some possess pulvinus (swollen leaf base) causing various leaf movements—spontaneous movement of lateral leaflets, sleep-movements at night, or sensitiveness to touch.

Economic Importance:

Economically the Leguminosae is one of the most important families of flowering plants. It provides many articles of food, fodder, timbers, dyes, gums, resins, fibres, oils and in addition to these there are numerous others grown domestically for ornaments. A few outstanding examples amongst the vast assemblage of its economic use has been mentioned earlier but for an agriculturist leguminous crops are more important as it enriches the fertility of the soil which is depleted by continuous cropping and must be included in an ideal crop rotation for poor soils.

Classificaton of Leguminous Crops:

I. MIMOSOIDEAE:

(a) Stamens more than 10.

1. **Tribe-Ingeae**: stamens united.

Genus: Albizzia (*A. lebbeck*-SIRIS or SIRIN-used for timber, fuel or shade for tea cultivation).

2. **Tribe-Acacieae**: stamens free, mostly trees (wattles); typical leaf-form bipinnate with infinite leaflets and small scaly stips.

Genus: Acacia.

A. arabica (BABUL)—a xerophyte, yields gum-arabic. *A. catechu* (KATHA)—a small prickly tree, yields catechu or cutch (used in tanning) and Katha used in beetle. *A. horrida*: forms good hedges or sandbinders. *A. melanoxylon*: yields valuable wood. *A. farnesiana*: gives sweetly scented flowers.

(b) Stamens as many or twice as many as petals.

3. **Tribe-Euminoseae**: anther glandless.

Genus: Mimosa—pod compressed, flat. (*M. pudica*—cultivated in gardens, flower heads pink; leaves sensitive to touch).

II. CAESALPINIOIDEAE:

A. Calyx in bud quite undivided or tubular below; leaves simple or one pair of leaflets. Androecium 10 or less.

1. **Tribe-Bauhinieae. Genus**: Bauhinia: flowers not papilionate, leaves of two equal lobes or parts. In the axils of the stipules are usually found small linear trichome structures; in some they form stout interstipular thorns. *B. variegata* (KACHNAR)—flowers pink or white, flower buds used as vegetable.

B. Calyx in bud quite or very nearly polysepalous; leaves some or all bipinnate, stamens usually 10.

2. **Tribe-Eucaesapinieae.**

Genus: Haematoxylon (*H. campechianum*—low wood—yields a dye known as haematoxylin).

Genus: Poinciana (*P. regia*-GOLD MOHUR—is a cultivated ornamental flowering tree and for avenue).

Genus: Caesalpinia—often hook climbers (*C. pulcherrima*—the peacock flower, cultivated in gardens. *C. coriaria*—used in tanning. *C. sappan*—yields dye. *C. bonducella*—Fevernut or KATKANJA—has medicinal importance).

Genus: Parkinsonia.

Many of the species belonging to this genus are cultivated as a hedge plant, wood yields good charcoal and leaves provide fodder.

(3) **Tribe-Cassieae**: anther basifixed opening by terminal pores.

Genus: Cassia—paripinnate leaves (*C. fistula*-AMALTAS—a cultivated garden tree. *C. javanica* and *C. glauca*: cultivated in gardens.)

(4) **Tribe-Amherstieae**: dorsifixed, no pores; ovary adnate behind to torus.

Genus: Tamarindus—(*T. indicus*—Tamarind, IMLI—large tree, flowers with three petals and three stamens; cultivated as ornamental plant; fruits are juicy lomentums—used as condiments and food).

Genus: Saraca (*S. indica*—ASHOKA—culitivated near temples as sacred plant or as ornamentals).

III. PAPILIONATAE:

A. stamens monadelphous or diadelphous

(a) Fruits lomentum:

1. **Tribe-Hedysareae:** Genus: Arachis.*

(b) Fruits legume or indehiscing pod: leaflets without stipels.

(i) Leaf simple or palmate. leaf with 3 entire leaflets:

2. **Tribe-Genisteae** (shrubs). Genus—**Crotalaria.***

3. **Tribe-Galegeae** (herbs). Genus—Indigofera—(*I. tinctoria*—NEEL—yields a dye).

Genus: Sesbania (*S. grandiflora*—AGASTH TREE planted on road side, flowers edible. *S. aegyptica*—JAIT—planted as hedge.

Genus: Cyamopsis (*C. psoralioides*—Guara—pod used as vegetable; also a good fodder crop).

4. **Tribe-Trifolieae**—includes many pasture and hay plants e.g. Genera: **Medicago** (Lucern and alfalfa), **Melilotus** (Senji), **Trifolium** (Clover), and the genus **Trigonella** whose seeds are used as condiments (*T. foenum or graceum or* METHI).

(ii) Leaves pinnate.

5. **Tribe-Viciae:** Rachis ending in a tendril.

Genera—**Cicer,*** **Pisum,*** **Vicia** (*V. faba*—cultivated for vegetable and fodder), **Lens** (*L. esculenta*—lentil or MASUR—is an important pulse crop), **Lathyrus** (*L. odoratus*—sweet pea or PHUL MATTER—is an ornamental).

6. **Tribe-Phaseoleae:** Rachis not ending in a tendril; pod dehiscing in two valves; stamens filamentous, diadelphous; ovary surrounded by disc.

Genera: **Phaseolus;*** **Cajanus*** **Glycine** (*G. sojasoyabean*-cultivated sparsely, pod is a rich source of food, also used as fodder); **Butea** (*B. frondosa*—the flame of the forest or DHAK or PALASH—wild or cultivated, the bark yields dye, leaves are joined together to serve the purpose of dishes (DONA) and the plant harbours lac insects); **Canavalia** (*C. ensiformis*—sword bean or BARA SEM—cultivated for its edible fruits); **Vigna** (*V. catjang*-Lobia—an important vegetable and fodder); **Dolichos** (*D. lablab*—SEM—an important vegetable; *D. biflorus*—KULTHE—both used as pulse and fodder crop).

7. **Tribe-Dalbergia**—includes important timber trees—*D. sissoo* and *latifolia.*

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*Genera whose names are followed by an asterisk are treated in the text.

Sub-family: PAPILIONATAE

Papilionatae is the biggest sub-family under Leguminosae including 10 tribes and about 317 genera. Although it is cosmopolitan in distribution but is more common in the temperate region, well represented in India. The sub-family is of great importance to man supplying food, vegetable and fodder; timber and fibre; dyes, shellac (host plant for shellac insects) and shola; useful green manure and along side many are also useful ornamentals. A few plants are important for supplying weight measures—*ratti* used by jewellers. Thus Papilionatae can be called the most important sub-family from an economic as well as agricultural points of views.

Familiar Genera: *Arachis* (groundnut), *Crotalaria* (sunnhemp), *Cicer* (gram), *Pisum* (pea), *Phaseolus* (green gram and black gram), *Cajanus* (pigeon pea), *Vigna* (cow pea), *Vicia* (vetch), *Dalbergia* (Indian red-wood), *Indigofera* (indigo) and others.

FLORAL CHARACTERS

Inflorescence: Indefinite, solitary or in spikes, racemose (usually) or heads, rarely cymose; either terminal or axillary.

Flowers: Various, mostly of moderate size, brightly coloured, sometimes very small and inconspicuous, bracteate or bracteolate; bisexual; zygomorphic, papilionaceous, hypogynous or slightly perigynous.

Calyx: Generally gamosepalous with five lobes or five triangular teeth, odd sepal anterior, segments ascending imbricate, often bilabiate from the greater union of the two upper and three lower segments respectively.

Corolla: Petals 5, papilionaceous, polypetalous, alternating with the calyx; aestivation with descending imbrication, i.e. the edges of the posterior petal being outside those of the lateral ones. The corolla is irregular and is made of a large posterior petal—the *'standard'* or vexillum, two lateral ones—the *'wings'* or alae and two lower ones which are united to form a *'keel'* or carina. The keel and the standard being twisted in such a manner as to form a good landing place for insects.

Androecium: Stamens 10, enclosed by the keel and inserted on the same level as the petals; cohesion monadelphous or diadelphous, or almost free or quite free. When diadelphous,

9 stamens are united leaving posterior free which is opposite to the standard.

Gynoecium: Carpel 1; ovary sessile or stalked; unilocular; superior; marginal placentation; style simple and unbranched; ovules in two alternating rows, generally anatropous.

Floral formula: † ☿ $K_{(5)}\, C_{1-2+(2)}\, A_{(9)+1}\, \underline{G_1}$

Pollination: The flowers are self-pollinated or cross-pollinated. Cross-pollination is attained by entomophily. The method of pollination is much interesting. The honey secreted by the inner sides of the bases of filaments is stored up in the staminal tube, round the base of the ovary. The tenth stamen is free from the tube and at the base, on both sides to it, are two openings leading to the honey. The keel and the tubular calyx also rigidly enclose and protect the essential organs. So the honey can be obtained only by fairly strong insects with moderately long tongues and observations show that Papilionatae are essentially *'bee-flowers'*. The insect alights upon the wings and depresses them by the weight of their body, whilst they probe for honey under the standard. The keel is joined by a protuberance to the wings and so the keel too is depressed. This causes the emergence of the stamen and stigma which rub against the underside of the insect visitor. The stigma usually comes out first. If the insect had already visited a similar flower, pollen grains from that flower stick to the body of the visitor and these are caught on the stigma, so that a fair chance of cross-pollination exists. The keel is kept in its place and, if repeated visits are necessary, is brought back into position by means of a lobe at the base of each wing which embraces the central rigid column of which ovary forms the axis.

In Müller's opinion there are four types of flower structures according to the way in which the pollen is applied to the bee: (a) Stamens and stigma return within the keel after a visit and they admit repeated visits. (b) The essential organs are confined under tension and explode and in these only one insect's visit is effective. (c) A piston–mechanism which squeezes the pollen in small quantities out of the apex of the keel and needs numerous insect visits. (d) The style having a brush of hairs which sweeps the pollen in small portions

out of the apex of the keel. These flowers also for the most part require repeated visits.

Cleistogamy is fairly common. Self-pollination usually occurs when the insect flies off, leaving the keel to return to its former position. But the pollen grains have generally no effect on the stigma of the same flower. In several cases the stigma in the unvisited flowers lies in the keel among the pollen, but it has been shown that it only becomes receptive (if young) when rubbed, so that autogamy does not necessarily occur.

Fruit: A legume or pod with two rows of ovules one alternating with the other.

Seed: Exalbuminous, radicle generally curved and accumbent (radicle against the edges of the cotyledons).

VEGETATIVE CHARACTERS

Habit: Herbs, shrubs or trees; some are twiners and tendril climbers, aquatics or xerophytes.

Germination: Usually epigeal, a few hypogeal.

Root: Tap root with tubercles.

Stem: Commonly erect; some have twining stems.

Leaf: Usually alternate, frequently stipulate and nearly always compound—digitately trifoliate to several foliate, pinnate or imparipinnate. Stipules usually free but may be adnate; stipels may also occur with individual leaflets. The leaflets in some cases are changed into tendrils and the stipules develope into big foliar structures looking like real leaves (e.g. *Pisum*). The leaf usually performs sleep-movements in the night and shows peculiar spontaneous movement by alteration of temperature. This is due to the pulvinus, present at the base, which is sensitive to light and temperature.

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Genus: Arachis

The genus Arachis comprises of 10 species commonly found in the warm countries of the Old World, Brazil and Paraguay. This belongs to the tribe Hedysareae with its typical constricted fruit (legume or pod) called *lomentum*, which breaks up into indehiscing one-seeded portions. The characteristic features of the genus are yellow flowers, pollinating by cleistogamy which is associated with geocarpy, i.e., production of the fruit underground, as is especially well seen in groundnut (*A. hypogaea*), where the flower-stalks grow downwards and bury the young fruits which ripen underground.

Arachis hypogaea Linn.

Hindi: CHINIABADAM *or* MOONGPHALI

English: Ground-Earth *or* Pea-nut

Arachis hypogaea or ground nut, one of the most common oilseeds and food crops, is a native of South America. It is essentially a tropical plant and requires a long growing season. It requires a certain amount of moisture but an excess of water is detrimental to its growth. It is grown for its edible seeds which yield an oil of great commercial value. The groundnut oil is either directly used or is decolourised, deodorised and hydrogenated to form 'margarine' in the west and *'vegetable ghee'* in India. It is another rival of olive oil both for food and soap. The oil cake forms a valuable fodder and is also used as manure. A new industrial use for groundnuts has been the manufacture of a textile fibre or artificial or synthetic wool under the name *'Ardil'* produced from the protein of groundnut.

The expansion of the cultivation of this crop is very recent due to its increasing commercial demand. The two fold advantages in taking this 'cash crop' in any crop-rotation are

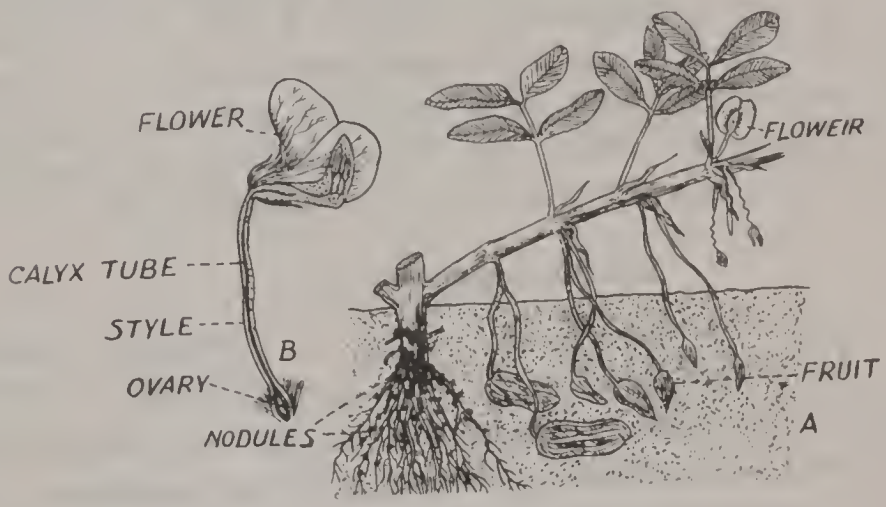
due to its resistance to drought, and its leguminous character and the nature of harvest which leave the soil fertile and friable.

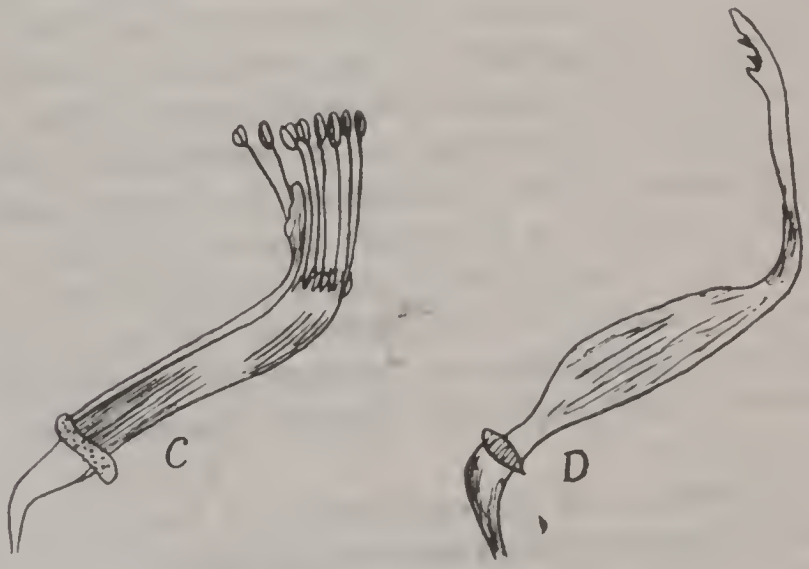
From the world standpoint, India produces the maximum amount of this crop. Although it is now cultivated in almost all the states of India, with a total annual cultivation of more than $12\frac{1}{2}$ million acres, yet the maximum acreage lies in Hyderabad, Bombay and Andhra.

BOTANICAL DESCRIPTION

Habit: Herbaceous annual producing fruit underground.

Root: A well developed tap-root with lateral branchings which are few near the surface and adventitious roots spring-





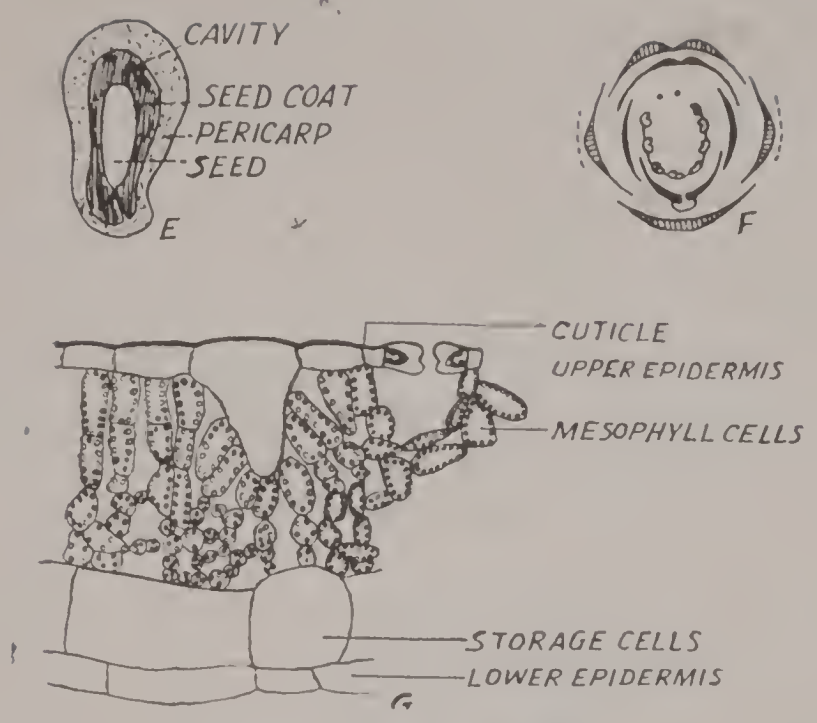


Fig. 30—**GROUNDNUT**

A. The plant. **B.** Flower showing the habit of forcing the ovary underground. **C.** Cohension of stamens (monadelphous). **D.** Pistil. **E.** Cross-section of fruit. **F.** Floral diagram. **G.** Anatomy of leaf.

ing from near the base of the plant and enter the soil; root hairs characteristically absent; root nodules conspicuously and profusely developed on the main root and lateral roots.

Stem: Low growing, spreading or prostrate, profusely branching and covering the ground over an area of 2'—3' in diameter; some varieties have an erect habit of growth. Internodes short, herbaceous, slightly woody at the base; more solid and cylindrical when young but become fistular and angular with age; hairy; branched—first branching arising from the axil of cotyledons and the subsequent branches are more or less decumbent, laterally borne on the erect central stem.

Leaf: Pinnately compound with two pairs of opposite leaflets; both radical and cauline leaves present; phyllotaxy distichous ($\frac{1}{2}$); stipulate, with two prominent angular stipules fused to the petiole—petiole long, hairy, with a ventral groove and pulvinus present at the base where the stipules become free; rachis not terminating into a leaflet; leaflets subsessile, entire, oblong to ovate, entire margined, margin hairy, apex obtuse, smooth above but hairy below, with reticulate unicos-

tate venation. The leaves show 'sleeping movements' in the night, the main petiole bends downwards and the leaflets move upwards until their upper surfaces are in contact, the two upper leaflets more or less enclosing the two lower ones.

Anatomical peculiarities :

The leaves are isobilateral with certain peculiarities for xerophytic habits:

(a) Cuticle is well developed on the upper surface.

(b) Some of the cells of the upper epidermis project inwards in a cone shape and contain tannins.

(c) Intercellular spaces between mesophyll cells are numerous.

(d) Water storage cells are present in immediate contact with lower epidermis.

Inflorescence: Flowers crowded in short axillary spikes or pedicelled in the axils of the leaves as solitary; flowers are more numerous towards the base of the plant; peduncle short and pubescent.

Flower: Small, yellow, pedicellate, papilionaceous, complete, zygomorphic, bisexual, bracteate–bract linear, bracteoles two. The flowers may be both aerial and subterranean (sometimes when a portion of a branch is covered with soil, flowers may form and bloom and the fruit may develop without appearing above ground).

Calyx: Sepals (5), gamosepalous, calyx tube long with five teeth, bilabiate–4 sepals united in one and one separate, hairy and green.

Corolla: Petals 5, inserted on the rim of the calyx tube papilionaceous; standard closing the wings, wings smaller; keels membranous, colourless, incurved, beaked in shape, enveloping the essential organs; aestivation with descending imbrication.

Androecium: Stamens are basically 10 [(8)+2 staminodes], two of which are sterile, monadelphous, 8 concrescent (united) in one bundle forming a closed tube while two are staminodes with their filaments fused with the staminal tube; anthers dimorphic–4 elongated versatile and 4 rounded subbasifixed these two kinds alternate with each other; dehiscence longitudinal.

Gynoecium: Monocarpellary; ovary superior, unilocular; style long, hairy, curved along with the keel, enclosed in the staminal tube, bearded at the tip; stigma terminal; ovules 1–5, anatropous. After the cleistogamic fertilization the flower stalk elongates, bends over and pushes the minute ovary into the soil where the pod begins to develop, and increases in size. It is very essential that the ovary be able to push itself into the soil or otherwise fruit formation does not take place (this is called *'geocarpy'*).

Floral Formula:

$$\dagger\ \varnothing\ Br_1\ Bracteoles_2\ K_{(4+1)}\ C_{1+2+(2)}\ A_{(4+4)+2\ \text{staminodes}}\ \underline{G_1}$$

Pollination: Cleistogamic.

Fruit: Lomentum (a constricted pod), reticulated with ten or more longitudinal and anastomising ridges and slightly swollen over the seeds. The wall consists of an outer spongy layer, a middle fibrous and woody layer and an internal papery layer which lines the pod. The fruit is indehiscent, ripens under ground by geocarpy, containing one to several ovoid seeds. The shell of the pod which contains the seed is morphologically the pericarp (pale and straw coloured) and the thin skin which covers the seed or nut is the seed coat or testa. The testa varies in colour in different varieties (brick red, russett or light tan).

Seed: Exalbuminous with thick, fleshy, white cotyledons containing plenty of oil; elongated or oval in shape, diagonally flattened and short beaked at the end, round, narrow or flattened at the other end, embryo—white.

Germination: Epigeal.

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Gensu: Crotalaria

Crotalaria is the largest genus belonging to the tribe Genisteae including nearly 350 species and commonly met in the warm regions of the globe. It includes shrubs or sometimes herbs with simple or digitately compound leaves and 3–7 entire leaflets and commonly stipulate. They produce legume and do not contain stipels. Stamens 10, monadelphous.

Crotalaria juncea Linn.

Hindi: SANAI, SAN *English*: Sunnhemp

Sunnhemp, the fibre of common cordage in India is one of the most important fibre yielding crop of this country and as a bast fibre, it ranks next to jute. The fibre is obtained from the stem by maceration in water. It is also a good fodder crop but more recently in tropical country it is being used for green manuring to renovate the infertile soils. In most parts of India it is grown as *"kharif"* crop and is more common throughout the plains.

BOTANICAL DESCRIPTION

Habit: It is a tall growing plant with a straight thin stem of about $\frac{1}{4}$ in. diameter which attains a height of 8 ft. when well grown.

Root: Deep rooted, with a long tap root and numerous branch roots all covered with bacterial nodules.

Stem: Aerial, erect, woody below and herbaceous above, ridged, silky pubescent. The stem has a very thin outer skin which contains the long bast fibres that comes out by the rotting of the softer tissue. The inner stem is woody and is a hollow cylinder filled with pith. Amount of branching varies with variety.

Leaf: Cauline, those on the lower part of the main stem appears basal; pinnately compound, trifoliate; alternate, phyllotaxy 2/5 or pentastichous; petiole short; stipules 2, minute,

persistent, simple, lanceolate, apex acute; leagets 3, lanceolate, apex acute, entire margin, surface shining with silky hairs especially on inner one, venation unicostate reticulate.

Inflorescence: As terminal yellow clusters of flowers in racemose having usually 12–20 flowers; sometimes branched.

Fig. 40—**SUNNHEMP**

A. A part of the inflorescence. **B.** Flower cut open, a few stamens removed. **C.** Back view of the flower. **D.** Fruit. **E.** Longitudinal section of the fruit, **F.** Seed. **G.** Floral diagram.

Flower: Pedicellate, pedicel short and silky; bracteate-bract small, green, apex acute and persistent; bracteolate—bracteoles 2, lateral, present at the base of the thalamus. The flowers are papilionaceous, complete, bisexual, zygomorphic and hypogynous.

Calyx: Sepals (5), gamosepalous; calyx tube sub-bilabiate, posterior lobe bifid and the anterior cordate trifid, in each lobe the sepals are united at the tip and the base while they are free in the middle; persistent; teeth linear with a broad base, hairy and yellowish-green coloured.

Corolla: Petals 5, free, papilionaceous, zygomorphic, standard prominent exceeding the wings, purple at the base, yellow above having a central midrib and a number of other nerves; wings less yellow and having a purplish tinge at the

base; keel beaked, curved and protecting the essential organs, lighter in colour than standard and wings; aestivation vexillary.

Androecium: Stamens 10 (5+5); monadelphous, united at the base but free above; dimorphic-five short and five long, those having short filaments have long anthers while those having long filaments possess round anthers; anthers 2-celled, basifixed, dehiscence longitudinal, introrse.

Gynoecium: Pistil 1; monocarpellary; ovary superior, unilocular, stalked, hairy; placentation marginal along ventral suture; ovules many, arranged in two alternating rows, amphitropous.

Floral Formula: † ☿ $K_{(2+3)}\ C_{1+2+(2)}\ A_{(5+5)}\ \underline{G_1}$

Pollination: Extensively cross pollinated. The flowers are self-sterile and self-pollination does not occur until the stigmatic surface is stimulated by insects or by some other agencies.

Fruit: A legume or pod, oblong, hairy, inflated with seeds and when dry the seeds get detached from its stalk and move freely inside the pod and rattle when shaken; dehiscence sutural.

Seed: Kidney-shaped.

Germination: Hypogeal.

The varieties differ in the period of maturity, branching habit and quality and quantity of the fibre which they yield.

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Genera: **Cicer** and **Pisum**

Cicer and Pisum belong to the tribe Vicieae, which contains herbs, with paripinnate leaves, the rachis ending in a tendril, or point and the stamens are diadelphous. Genus Cicer includes 14 species, cultivated mostly in Western Asia while Pisum includes 6 species, found in the Mediterranean area and Western Asia.

Differentiating Characters of Cicer and Pisum:

1. **Cicer:** Herb, erect or spreading; stipules adnate; leaflets small and more in number (12–14), rachis terminates usually with a leaflet; pods usually with 1-2 seeds; seeds somewhat triangular with brown, reddish, black or white seed coat.

2. **Pisum:** A tendril climber; stipule leaflike, replacing as assimilating organs the leaflets, which have become tendrils; leaflets few in number (2–6); rachis terminates into a pinnate tendril; legumes with 4–6 seeds; seeds more round, marbled and compressed.

Cicer arietinum Linn.

Hindi: CHENA, CHOLA, BOOT

English: Gram, Bengal gram *or* Chick pea

Gram, the most common of all pulses in India, is probably a native of S. W. Asia. It is known in this country for a long time and is cultivated as a *rabi* crop over 21 million acres annually but mostly found in the north (Uttar Pradesh, Punjab, Rajasthan, Madhya Bharat, Madhya Pradesh). It is used for human consumption as well as for feeding animals for its high protein value. Its cultivation appreciably improves the land due to its deep and tubercled roots. Apart from its use as a pulse crop, the acid secretion (malic and oxalic) from pods and leaves is known from the remotest antiquity and is a valuable substance to be used both in medicine and diet.

BOTANICAL DESCRIPTION

Habit: A viscid much branched glandular pubescent annual herb attaining a height of 2 ft. and above. The plants may be erect or spreading which are apparent at early stages but at the time of flowering, all types appear more or less erect. The plants possess a bluish green colour with a little ashy grey bloom over the leaves and stems.

Root: A well developed deeply penetrating tap root system. The central tap root contains numerous lateral branches on the upper part (generally 4 rows) which spread out in all directions. The roots contain tubercles.

Stem: Herbaceous, woody below; erect or spreading depending on variety; branching racemose; ridged, hairy, cylindrical with internodes short and green.

Leaf: Pinnately compound, bi-pinnate, rigid; rachis usually terminating to a leaflet; stipules large, ovate, strongly serrate; phyllotaxy ($\frac{1}{2}$) distichous; the number and size of leaflets vary in different types or varieties, usually 12–14 (more than 5), leaflets simple, opposite or alternate, oval to oblong or obovate in outline serrated edges, acute apex, reticulate unicostate venation, covered with glandular hairs which secrete an acid fluid sour in taste; petiole short. The colour of the foliage varies considerably in different types and with the age of the plant.

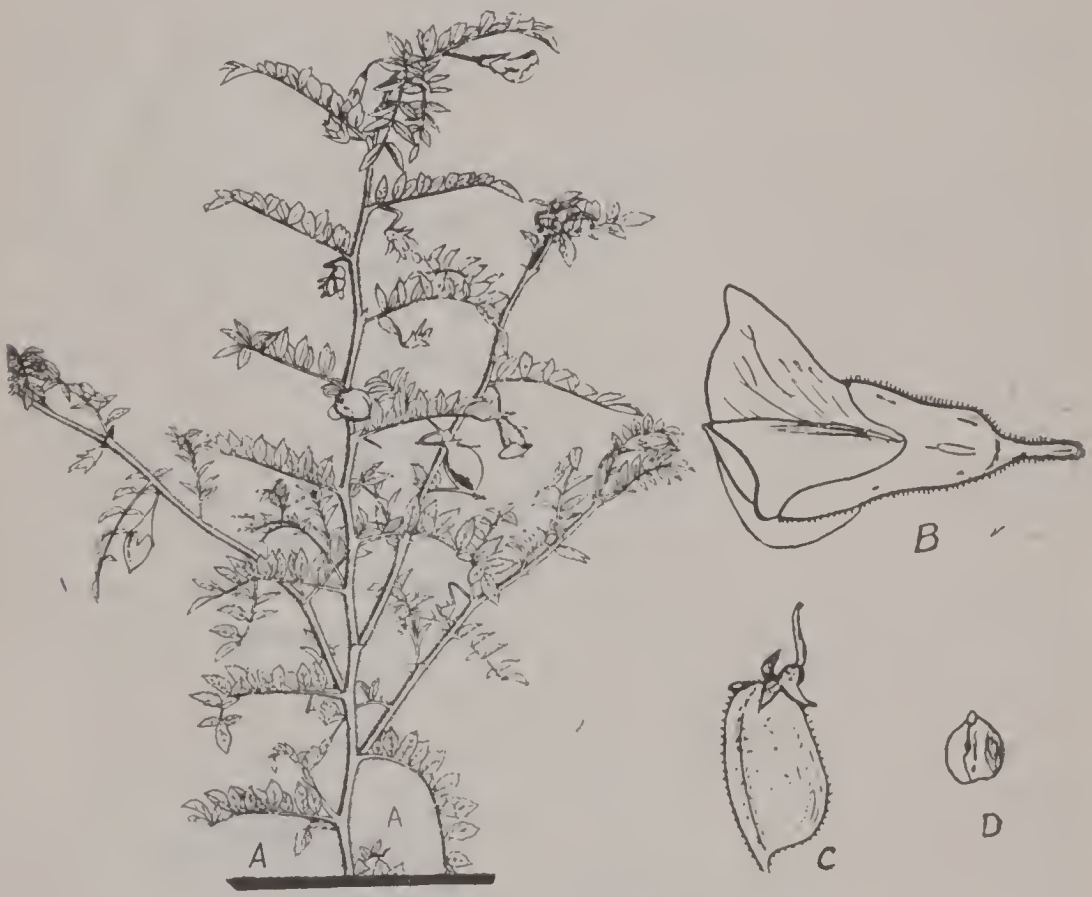

Fig. 41—**GRAM**

A. A portion of the plant with flowers. **B.** Flowers. **C.** Fruit. **D.** Seed.

Inflorescence: Axillary, solitary, develop at the node opposite to the leaf on short jointed pedicel; the lowest buds open first and the cymose arrangement of the flowers can be easily seen.

Flower: Pedicellate; bracteate—bract small, linear, two minute structures are also visible by the side and at the base of the bract; complete, bisexual, zygomorphic, hypogynous, papilionaceous. The colour of the flower may be white, greenish-white, some shades of pink, lilac or blue—depending on the variety and age of the flower. The buds open during the day time and close in the late afternoon.

Calyx: Sepals (5), gamosepalous, calyx tube oblique; bilabiate——two sepals united in one group while remaining three in another; teeth lanceolate, green, entire, hairy, reddish tipped and apex acute.

Corolla: Petals 5, free, variously coloured, papilionaceous —consisting of one standard, two wings and two keels (united) as different irregular petals typically arranged; standard broad exceeding the wings and keel having one midrib and a number of veins; wings free from the keel; keel incurved enclosing the essential organs and the lower end of the keel is free forming two sharp claws.

Androecium: Stamens 10 [(9)+1], diadelphous by the cohesion of (9) stamens in the form of a tube and leaving the posterior stamen free; anthers yellow, 2-celled, dorsifixd, uniform with longitudinal introrse dehiscence.

Gynoecium: Monocarpellary; ovary superior, sessile, hairy, green; placentation marginal; two or many ovuled, ovules anatropous; style incurved, beardless but hairy at the base and glabrous above; stigma capitate.

Floral formula: † ☿ $K_{(5)}\, C_{1+2+(2)}\, A_{(9)+1}\, \underline{G_1}$

Pollination: Self-pollinated as a rule and the pollination is over much before the opening of flowers. Cross-pollination can also possibly take place by entomophily to the extent of 5—10 per cent.

Sterility: Sterility in gram, i.e. development of pod without seed is an important factor determining the yield of gram. Sterility may be a genetic factor inherent in the variety or may be caused by the failure of pollination owing to unfavourable climatic conditions.

Fruit: An inflated legume or pod; sessile, short, oblong, turgid, usually containing two seeds (1—3 seeds also occur).

Seed: Somewhat triangular—obovate or sub-globose, beaked; vary in colour, size and smoothness of the surface according

to variety; the seed coat may be reddish brown, black or white; the surface may be smooth, puckered, granulated or rough; exalbuminous; cotyledons rich in proteids and having a high food value.

Germination: Hypogeal.

Varieties differ in colour and size of flowers and pods along with the colour, size, smoothness of surface, shape, quality and weight of the seed.

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Pisum arvense Linn.

Hindi: DESI MATAR, KERAO *English*: Field pea

The pea probably originated in Western Asia extending eastwards to the Himalayas including North India. It is one of the most important species of the group of legumes serving the double purpose of a pulse as well as a vegetable in its green stage. It differs from all other vegetables in the meat substi-

tutes, which it contains. Two species of cultivated peas are known in India: purple flowered peas, *Pisum arvense* Linn., known as DESI MATAR or KERAO and white flowered peas, *Pisum sativum* Linn., known as MATAR. Peas do not stand

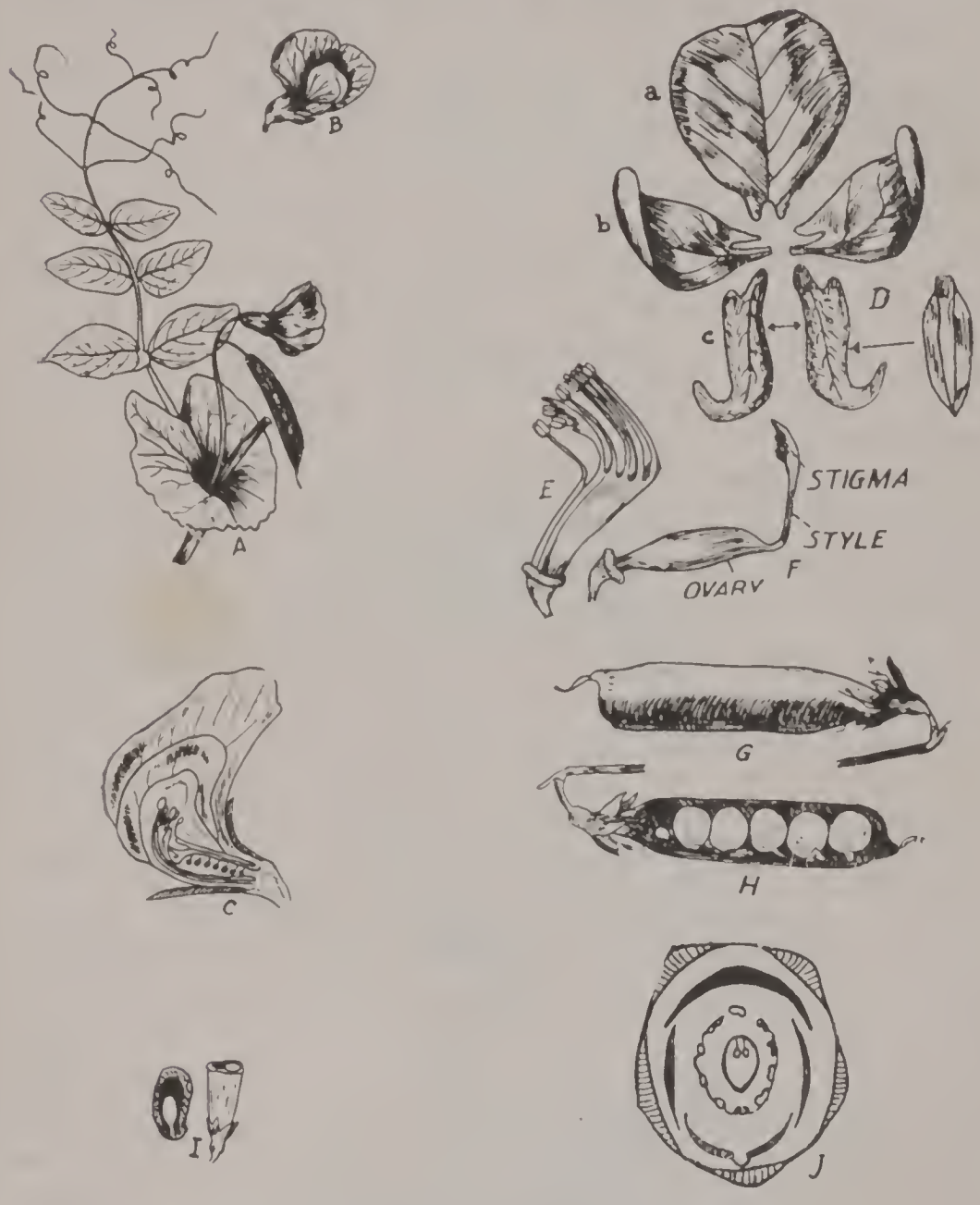


Fig. 42—**PEA**

A. A branch. **B.** Flower. **C.** Longitudinal section of flower. **D.** Corolla dissected out.; (a) standard; (b) wing; (c) keel. **E.** Stamens (9)+1 and pistil. **F.** Pistil. **G.** Fruit (legume). **H.** Longitudinal section of fruit. **I.** Transverse section of ovary. **J.** Floral diagram.

long continued rain and are usually planted towards the end of rains. In districts of 20″ rainfall or under, it is sown at the beginning of rains. *Pisum arvense,* believed to be an older

cultivated form, is commonly grown as *'rabi'* crop in Northern India. U. P. and Bihar stand foremost in acreage and production.

BOTANICAL DESCRIPTION

Habit: A cultivated annual herb, climbing by tendrils which are modifications of the upper leaflets.

Root: A well developed tap root, branched, covered with nodules.

Stem: Semi-erect, when support is available, it has a tendency to climb by means of tendrils; herbaceous, slender, hollow; powdery over the surface; ridged and cylindrical. Branching is variable with few or many lateral branches. The stem grows to a height of about 2-3 ft. Field pea is less vigorous than garden pea.

Leaf: Pinnately compound with 1—3 pairs of leaflets, the terminal ones (one or more) being modified into tendrils which are very sensitive to touch and prehensile by the aid of which the plants are able to climb; pulvinus present; phyllotaxy alternate ($\frac{1}{2}$); leaflets ovate with mucronate tips, serrated margin at the base but entire at the apex with reticulate unicostate venation, stipules large, leafy, denticulate at the base.

Inflorescence: Axillary with peduncle, either solitary or in a few flowered (1—3) raceme.

Flower: Usually purple coloured, bisexual, complete, zygomorphic, pedicellate, bracteate and papilionaceous.

Calyx: Sepals (5), gamosepalous, united into an oblique tube with five lobes, lobes acute, sepals possess a prominent vein, persistent.

Corolla: Petals 5, free, papilionaceous, with vexillary aestivation; standard large, pink coloured with greenish base, veined; wings with green base and reddish top, veined and cover the innermost jointed petals (keels): keels are yellowish in colour, much curved and surround the essential organs.

Androecium: Stamens 10 [(9) + 1], diadelphous, 9 filaments united to form a tube surronding the style, posterior one remaining free; filaments alternately longer and shorter, anthers dorsifixed, dehiscence longitudinal.

Gynoecium: Pistil 1, monocarpellary; ovary subsessile, unilocular, superior; few ovuled, ovules more or less campylotropous; placentation marginal; style 1, inflexed; the stigma

is placed at the end of the curved style which bears a number of hairs on its concave or upper side.

Floral formula: † ☿ $K_{(5)}\ C_{1+2+(2)}\ A_{(9)+1}\ \underline{G_1}$

Pollination: Self-pollination normally occurs but cross-pollination may be brought by entomophily; flowers secrete honey and protandrous.

Fruit: A pod or legume with a few seeds (2—10); the pod dehisces by both sutures, the splitting is due to the contraction of the endocarp (parchment-like sclerenchymatous membrane).

Seed: Exalbuminous, smooth, wrinkled or indented, cotyledons rich in starch and proteids.

Germination: Hypogeal.

Varieties differ in size, colour, smoothness of surface, weight and quality of seeds.

Genera: PHASEOLUS AND CAJANUS

Both the genera Phaseolus and Cajanus belong to the tribe Phaseoleae which is characterized by possessing climbing herb, or more rarely erect or shrubby (*Cajanus*), very rarely trees. Leaves pinnate, generally trifoliate; leaflets usually with stipels; stamens generally diadelphous. It contains 47 genera generally distributed throughout the tropical and warmer regions of the earth.

Phaseolus is the largest genus of the tribe consisting of 160 species and distributed in the tropical and warm temperate regions. They possess generally herbaceous twining stem and the flower is characterized by the spiral coiling of the keel with the inclosed style. The mechanism of pollen presentation in Phaseolus is typical of its kind and is similar to that of Lathyrus, Pisum and Vicia. The pollen is shed early by the anthers into the apex of the keel. The style possesses a brush of hairs at its top which carries out the pollen in small portions out of the apex of the keel when the latter is depressed. The important cultivated species of the genus Phaseolus are: *P. multiflorus* (scarlet runner); *P. vulgaris* (French or kidney bean); *P. lunatus* (lime or duffin bean); *P. mungo* (black gram) and *P. radiatus* (green gram) which are highly valued as vegetables, pulses and cattle feeds (specially horses).

The genus Cajanus consists of a single species *Cajanus indicus* Spreng or *Cajanus cajan* Linn. (pigeon pea or Congo

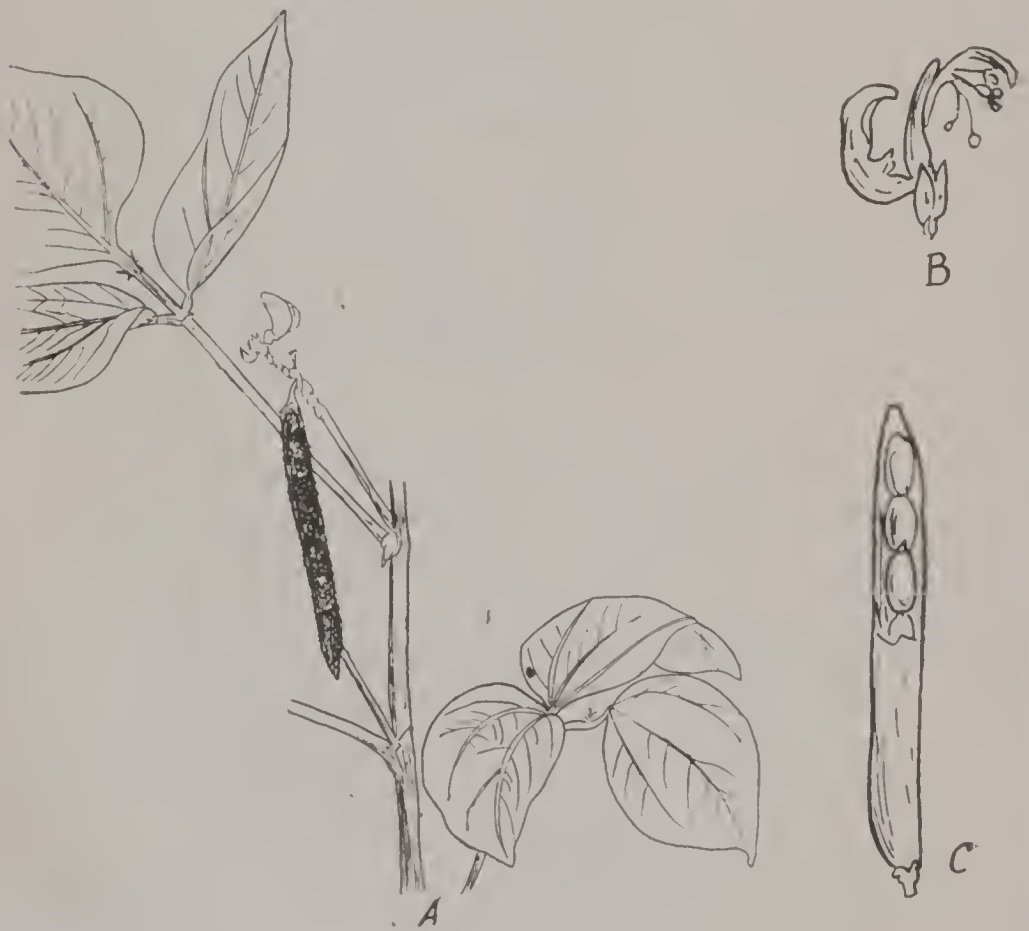
pea, ARHAR) and hence the characters of the genus will be discussed with the species.

The prominent differentiating characters between the genera Phaseolus and Cajanus are their habit—spreading and procumbent in the former while erect and tall in the latter; leaf form—petiolate, ovate, linear in the former and subsessile, oblong, lanceolate in the latter; flower colour—lighter yellow in Phaseolus; kind of fruit or pod and seed—oblong in Phaseolus with a typical hilum or scar while round in case of Cajanus.

Phaseolus mungo Linn.

Hindi: TIKARI KALAI *or* URD *English*: Black gram

Black gram or URD (*P. mungo*) and green gram or MUNG (*P. aureus* or *P. radiatus*) are both important pulse crops grown throughout India. They are commonly cultivated as dry crops in areas of scanty rainfall (35″). They are extensively used for human consumption but also form important cattle feeds particularly for horses. Black gram is popularly used for cake



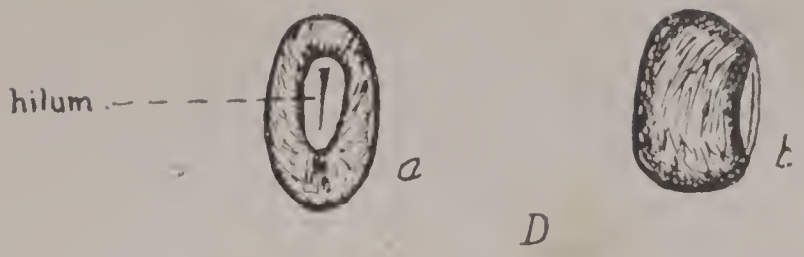


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Fig. 43—**BLACK GRAM**

A. A portion of the stem showing leaf, flower and fruit. **B.** Flower cut open. **C.** Fruit. **D.** Seed. **E.** A twig of country bean showing flowers and trifoliate leave.

preparation due to its peculiar property of becoming a mucilagenous mass when ground with water.

BOTANICAL DESCRIPTION

Habit: A cultivated annual herb, very hairy, spreading annularly with procumbent branches and is to all appearances very much like green gram.

Root: Tap root, much branched and possesses nodules (tubercles). The roots may be shallow (mesophytic) or deep (xerophytic).

Stem: Aerial, suberect; diffusely branched; covered with fairly long rough brown hairs ("wooly pyrol") and these hairs are larger than green gram; herbaceous; twining; pigmented; cylindrical, having two longitudinal ridges; rough, with nodes and internodes.

Leaf: Pinnately compound, trifoliate with pulvinus base; stipulate, stipules two, ovate, linear with basal appendage, entire, rough, with acute apex; stipels present, small; petiolate, having a long petiole; leaflets 3, hairy generally with purplish tinge, membranous, rough, broad, ovate to rhombic-ovate in outline, acuminate and entire, venation reticulate, unicostate. The colour usually is either light green or dark green but lighter than that of green gram.

Inflorescence: Consists of a cluster of 5-6 flowers at the top of a long stout hairy peduncle. It is axillary, branched racemose, raceme of some of the lower flowers remain undeveloped.

Flower: Pale or lemon yellow. pedicellate, bracteate, bracteolate, complete, hermaphrodite, zygomorphic and hypogynous.

Calyx: Sepals (5), gamosepalous, calyx tube campanulate, bilabiate; lower tooth usually longer than the rest, extending to about half the lengh of the flower, 2-lobes are fused together to form bigger lobe, with a slight notch at the apex; apex acute, margin entire, hairy.

Corolla: Yellow, papilionaceous, having a standard, two wings and a keel as usual but complicated by the spiral coiling of the keel with the inclosed style and having a terminal horn-like appendage.

Androecium: Stamens 10, diadelphous (9)+1; anthers uniform; filaments joined below to form a tube enclosing the style, leaving the posterior free while the filament tops are free.

Gynoecium: Monocarpellary; ovary superior, sessile; style filiform and bearded below the stigma: stigma lateral and subterminal with the style projecting as a short narrow terete appendage, style curved and twisted along the keel; ovules many, anatropous; placentation marginal.

Floral formula: † ☿ Br_1 $Bracteoles_2$ $K_{(3+2)}$ $C_{1+2+(2)}$ $A_{(9)+1}$ $\underline{G_1}$

Pollination: Universally self-fertilized and fertilization is over before the opening of flowers; cross-pollination by entomophily is only to a limited extent. The method of pollen presentation is typical to the genus.

Fruit: A slender pod with a short hooked beak, subcylindrical, erect or spreading with fairly long, deciduous, silky hairs; containing 4—10 seeds: distinctly septate between the seeds and with sutural dehiscence.

Seed: Exalbuminous, oblong in shape and are either black, very dark brown or occasionally even greenish with a concave white hilum. The colour of the split seed is white. They are very high in proteids and comparable to the proteids from animal sources. The black gram seeds peculiarly differ from other pulses in the way that it forms a somewhat mucilagenous pasty mass when ground with water. Like glutens in wheat, this property of black gram increases the *"raising"* in the various cakes made from it and lightens them.

Germination: Epigeal.

Distinguishing differences between black gram and green gram:

	Black Gram (*P. mungo*)	Green Gram (*P. radiatus*)
1.	*Habit*:	
	Slightly shorter and more dark in appearance.	Slightly taller, less dark and more green.
2.	*Hairs on vegetative parts and pods*:	
	Longer.	Shorter.
3.	*Colour of leaves*:	
	Green to dark green.	Lighter green.
4.	*Hilum or Scar*:	
	Concave in shape.	Not concave.
5.	*Seed colour*:	
	Usually black or dark green.	Commonly green with smaller size.
6.	*Split pulse*:	
	White or pale cream.	Yellow.

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Cajanus indicus Spreng.

(*Cajanus cajan* Linn.)

Hindi: ARHAR (late) TUR (early) *English*: Pigeon pea

Pigeon pea, a native of Africa, today forms an important Indian pulse and is widely cultivated throughout this country. Amongst the various states, Bihar, Madhya Pradesh, Bengal and Uttar Pradesh produce maximum amount of this crop. It is usually sown as mixed with other *'khrif'* crops. The seed is important for its high protein content and thus enters into the daily food of a considerable number of people. It is consumed primarily in the form of split pulse or 'DAL', while its tender green pods constitute a very favourite vegetable to many people. The outer integuments of its seed together with part of the kernel provide a valuable food for milch cattle. The stalks are utilized for various purposes, such as roofing, wattling sides of carts and basket making. It is also a useful restorative crop and forms part of a good rotation, more particularly in poor soils.

BOTANICAL DESCRIPTION

Habit: Erect, tall, late maturing shrub, although cultivated as annual (8–11 months crop) but can stand as perennial.

Root: Tap root, much branched, covered with nodules, lateral roots are much longer in case of spreading types than in the erect forms. Roots penetrate deep and are extensive, the character of which is utilized for renovating the soil. The root system appears to be closely related to the habit of growth.

Stem: Erect, strong, woody below and herbaceous above, cylindrical with nodes and internodes, green, striped, grooved

with grey silky hairs all over; branching racemose and wide spreading. The point on the main stem where branching begins, the number of secondary branches and the angle at which these are given off vary with different varieties.

Leaf: Pinnately compound, trifoliate; stipules two clasping the stem, linear, entire, acute, having silky white hairs;

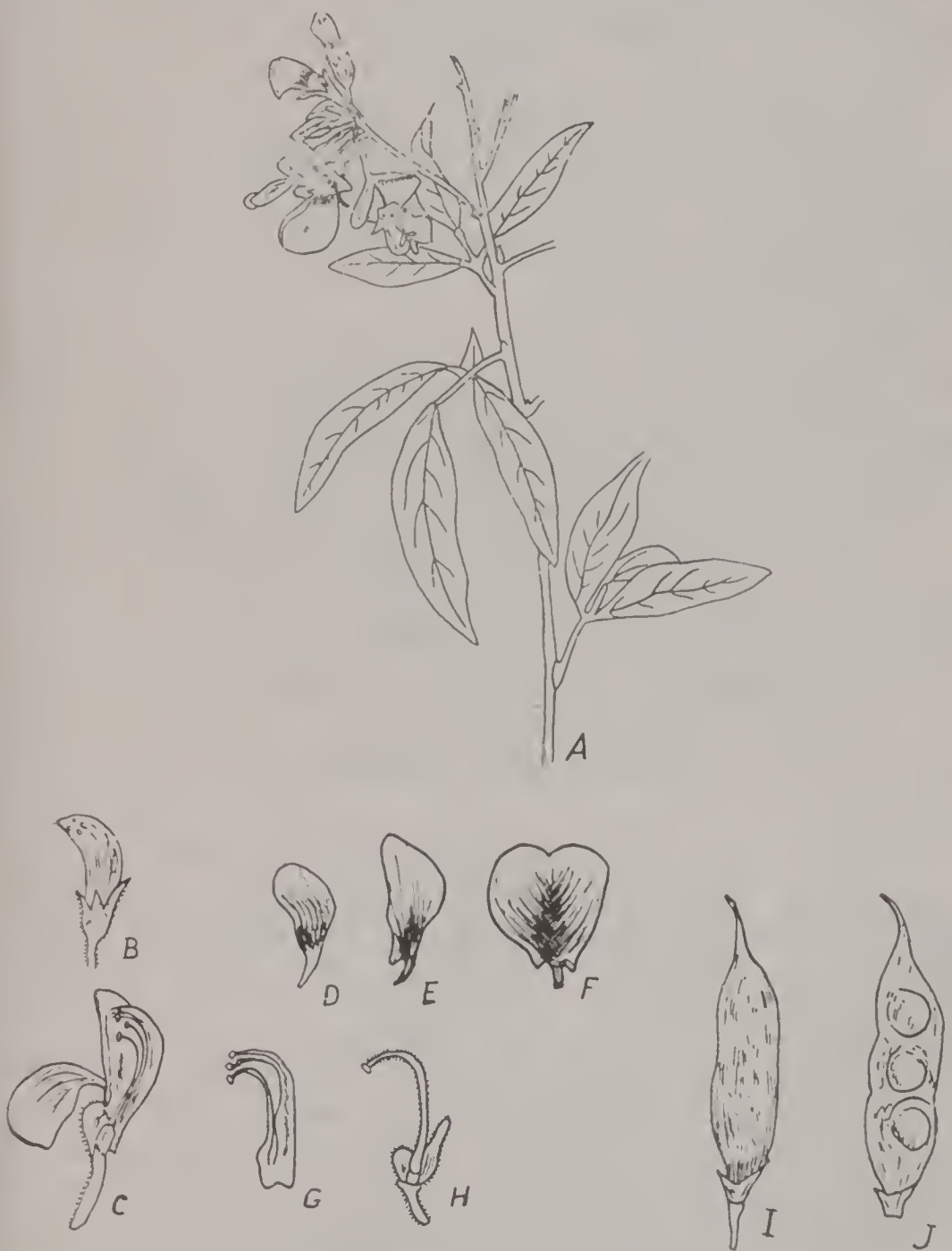

Fig. 44—**PIGEON PEA**

A. A part of the stem with flowers and leaves. **B.** A flower bud. **C.** Flower cut open. **D.** Keel. **E.** Wing. **F.** Standard. **G.** Longitudinal section of the androecium showing the cohesion of stmens. **H.** Pistil. **I, J.** Fruit.

petiole having a groove on the dorsal side; leaflets subsessile entire, lanceolate to narrow-elliptical, acute, softly pubescent on both surfaces and dotted with numerous minute resinous glands (densely silky) on the lower surface; base pulvinus; venation reticulate unicostate; phyllotaxy alternate—1/3 in early stages but becomes 2/5 afterwards. The total length of the leaf, and also the size, shape, and texture of the leaflets and tone of the colour of the foliage, differ in the various types or varieties.

Inflorescence: An axillary raceme, branched and found in the upper branches of the bush or often forming a terminal panicle (corymbs). The flowers are either more or less grouped together at the end of the branches (ARHAR) or distributed along the branches (TUR).

Flower: Pedicellate, bisexual, complete, irregular, hypogynous, distinctly papilionaceous; usually yellow in colour with brownish back. The crop is characterized by the great extent of its flowering period and by the great number of flowers that it produces but a considerable number of which shed off without setting, this shedding being greatly influenced by weather conditions. The colour of the flower is a chief distinguishing feature in the identificaton of varieties.

Calyx: Sepals (5), gamosepalous, calyx tube campanulate, two inner sepals have fused to form a single lobe; lobes linear, acute, entire, hairy, green, sharply pointed and reddish at the tip.

Corolla: Petals 5, free, papilionaceous—standard one, large, broad, auricled at the base, yellow and veined with black and blotched yellow; wings two, end in pointed claw at the base; keel obtuse and much incurved, covering the essential organs.

Androecium: Stamens 10 [(9)+1] diadelphous, 9 united in one and posterior remaining free; anthers uniform, basifixed but filaments alternately longer and shorter—thus the anthers appear in two groups, five above and five below. In young buds the stigma lies above the level of the anthers but with the development of the bud, the filaments elongate bringing the top five anthers to the level of the stigma. This stage is completed before the bursting of the anthers, which occurs in the bud a day before the flower opens.

Gynoecium: Monocarpellary; ovary superior, sub-sessile, pubescent; ovules anatropous, usually 4 (3—5); placentation marginal: style long, thickened upwards, beardless and persistent in the young fruit; stigma terminal, capitate, uncurved.

Floral formula: † ☿ $K_{(3)+2}$ $C_{1+2+(2)}$ $A_{(9)+1}$ $\underline{G_1}$

Pollination: In spite of the fact that the stigma is completely covered with the pollen of the same flower but becomes receptive only after being rubbed, autogamy thus does not necessarily occur. Cross pollination is brought by insects.

Fruit: A legume or pod with 2—5 seeds; the late varieties (ARHAR) contain more seeds in their pods (usually 3—5) while the early varieties (TUR) contain less (usually 2-3); pods depressed obliquely (beaded) or may not be (unbeaded). The colour of the fruit varies from green to dark with the intermediate form as green with dark maroon blotches. The fruit is densely glandular, pilose.

Seed: Orbicular and compressed with one edge flattened; exalbuminous; cotyledons laden with proteids; vary much in colour, majority being brown with small white hilum.

Germination: Epigeal.

Good improved varieties of *Cajanus indicus* are of early maturity, high yielding, with good cooking quality and resistant to unfavourable weather conditions and wilt disease.

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CHAPTER XI

Order: UMBELLIFLORAE

The order Umbelliflorae is characterized by a simplification or reduction in the floral parts which is frequently associated with epigyny and by a tendency of the flowers to aggregate in a head (umbel) which facilitates insect pollination. The flowers are typically bisexual, regular, cyclic (polypetalous), epigynous, generally 4-5-merous with one series of stamens carpels often reduced to two, ovules solitary in each chamber, pendulous, anatropous, with one integument and an outwardly directed micropyle. Seed endospermic with small embryo.

Rendle has circumscribed 3 families under this order—Araliaceae, Umbelliferae and Cornaceae—of which Umbelliferae only will be dealt here.

Family: UMBELLIFERAE

The family Umbelliferae comprises of about 125 genera and 2900 species which are more or less cosmopolitan in distribution but chiefly met in the north temperate climate.

The family consists almost entirely of herbs with aromatic flavour and can be easily identified by its typical umbellate inflorescence, free and pentamerous perianth and androecium, and bilocular, 2-carpellate, inferior ovary which develops into a schizocarpic fruit.

Familiar Examples:

Fennel or SAUNF (*Foeniculum vulgaris*); coriander or DHANIA (*Coriandrum sativum*); carrot or GAJAR (*Daucus carota*); AJOWAIN (*Carum copticum*); cumin or SAFED-JIRA (*Cuminum cyminum*); parsnip or SOWA (*Peucedanum*); asafoetida or HING (*Ferula foetida*).

FLORAL CHARACTERS

Inflorescence: An indeterminate umbel which may be simple or compound and often subtended by an involucre of

free simple or compound bracts which are sometimes caducous and persistent in fruit or deciduous. Sometimes the pedicels are very much reduced and appear as 'head'.

Flower: Small, regular or zygomorphic, epigynous, bisexual or polygamous, epigynous, pentamerous, outer flowers sometimes rayed; bracts and bracteoles involucrate; perianth in two whorls; often showy with various colours.

Calyx: Sepals 5, free or united, small, calyx tube 5 lobed, adnate to the ovary and only the lobes are distinct and often reduced to teeth.

Corolla: Petals 5, free, often unequal, margin usually inflexed, epigynous, usually imbricate in bud, sometimes valvate.

Androecium: Stamens 5, free, alternating with petals arising from an epigynous disc; anthers 2-celled, basifixed or dorsifixed with longitudinal dehiscence.

Gynoecium: Carpels (2), syncarpous; pistil 1, ovary inferior, bilocular, crowned by a 2-lobed disc, ovule solitary in each locule, anatropous, pendulous, raphe ventral and integument one, styles 2; stigmas 2, capitate, surrounded by a honey disc.

Floral Formula: ⊕ or † ☿ $K_{5 \text{ or } (5)}$ or o C_5 A_5 $\underline{G}_{(2)}$

Pollination: Cross-pollinated by entomophily. The following characters in these plants attract insects to attain pollination: massing of flowers into a dense inflorescence makes them conspicuous and this is aided by the enlarged petals of the marginal flowers; the honey secreted by the hypogynous disc is easily accessible; the plants possess high fragrance. Self-pollination is prevented by marked protandry in flowers.

Fruit: A schizocarp, composed of two indehiscent carpels, laterally or dorsally compressed, breaking up into two parts, called *mericarps,* each attached to a slender, often forked axis (*carpophore*); the mericarps usually with five longitudinal ridges and traversed by oil-canals *(vittae).*

Seed: 2, solitary in each carpel, pendulous from the point of attachment to the carpophore; testa thin; albumen cartilaginous; embryo minute, straight, near the apex of the seed; radicle superior.

VEGETATIVE CHARACTERS

Habit: Mostly biennial or perennial herbs (rarely shrubs) with aromatic odour.

Germination: Usually epigeal.

Root: Tap root, branched, sometimes swollen for food storage.

Stem: Herbaceous, erect or prostrate, sometimes ridged, usually fistular caused by the drying of the pith at maturity.

Leaf: Alternate, simple or usually much dissected or pinnately or palmately compound, sometimes heteromorphic, petiole usually sheathing at the base, exstipulate.

Economic Importance:

Umbelliferae is economically much useful for supplying a number of valuable products. *Vegetable food*: carrot (*Daucus*), parsnip (*Pastinaca*), celery (*Apium*) and parsley (*Petroselinum*); *fodder*: carrot, wild parsley, cowparsnip (*Heracleum sp.*), angelicas (*Angelica sp.*); *condiments*: anise (*Pimpinella*), AJWAIN (*Carum*), ZIRA (*Cuminum*), fennel or SAUNF (*Foeniculum*), coriander or DHANIA (*Coriandrum*); some of these mentioned species also possess great medicinal value including BRAHMI (*Hydrocotyle*); some are also popular as ornamentals. A number of species belonging to this family possess resins or alkaloids in lethally poisonous quantities when the parts, especially roots and fruits, are eaten.

Genus: **Coriandrum**

The genus Coriandrum includes only 3 species which are commonly met in the Mediterranean climate. These are glabrous strong smelling annual herbs with decompound leaves, the ultimate segments being almost filiform. The inflorescence is a compound umbel with few rays; either ebracteate or when present the bracts are few and filiform. The flowers are white or purplish with small, acute and unequal teethed calyx tube and obovate, emarginate and equal sized, radiant petals which are generally unequal in outer flowers. Fruit subglobose; with unprominent ridges; vittae obscure, solitary, under the secondary ridges; carpels slightly concave on the inner face; carpophore bipartite, seed convex-concave.

Coriandrum sativum Linn.

Hindi: DHANIA *English*: Coriander

Coriander seeds have been found in the Egyptian tomb of the tenth century B.C. Both the seeds and leaves are used for seasoning soups and salads. The seeds are of commercial im-

Fig. 45—**CORIANDER**

A. A branch with leaf and inflorescence; a, flowers; b, fruits. **B.** (1) Lower leaf; (2) Upper leaf. **C.** Flower. **D, E. Floral** parts. **F.** Ovary. **G.** Fruit. **H.** Dissected fruit; (a) carpophore; (b) mericarp. **I.** Longitudinal section of fruit.

portance both as a spice and for the oil extracted by distillation. The seeds also have medicinal properties. It is a typical black cotton soil crop but grows on a variety of soils and requires almost the same climatic condition as rice but less rainfall.

BOTANICAL DESCRIPTION

Habit: An annual plant, glabrous, cultivated for its leaves (vegetable) and fruits (condiment).

Root: Branched tap root.

Stem: Erect, cylindrical, herbaceous, hollow, glaucous and branched.

Inflorescence: Compound umbels with 5–10 rays, usually ebracteate or may be composed of I, small setaceous bract, the involucel contains usually 3, short linear-lanceolate bracts.

Flower: Ebracteate, pedicellate, complete, regular, bisexual, cyclic, epigynous.

Calyx: Sepals 5, small, free or united, slightly petaloid.

Corolla: Petals 5, free, apically inflexed, white, petals of the outer flowers are slightly zygomorphic.

Androecium: Stamens 5, polyandrous, filaments long, anthers dorsifixed.

Gynoecium: Carpels (2), syncarpous; ovary inferior with hypogynous disc; ovary bilocular with one pendulous ovule in each locule; style absent; stigmas 2 arising from the disc.

Floral Formula: ⊕ or † ☿ $K_5\ C_5\ A_5\ \underline{G}_{(2)}$

Pollination: Cross pollinated by entomophily.

Fruit: Cremocarp, oblong, ridged.

Seed: One in each carpel, endospermic with minute straight embryo.

Genus: **Daucus**

Daucus is a bigger genus as compared to other genera of Umbelliferae and comprises of nearly 60 species of wide geographical distribution. A few species are known to be natives of North America. Except carrot (*Daucus carota* Linn.) no other species has any great importance in cultivation.

The plants are annual or biennial herbs and usually hispid. The leaves are 2–4 pinnate and the ultimate segments are narrow or small. Inflorescence is a compound umbel with indefinite number of rays and with numerous

bracts and bracteoles (bracteoles may be sometimes absent). Flower white; calyx tube teethed which may be small or obsolete; petals obovate, emarginate, outer often radiant. Fruit elliptic, terete, dorsally compressed a little and ridged; vittae solitary under the secondary ridges, carpophore undivided or bifid. Seed dorsally subcompressed with a plain inner face.

Daucus carota Linn.

Hindi: GAJAR *English*: Carrot

Carrot is a popular vegetable grown for its edible root and also used in confectionary for preparing sweet meats and in many Indian household preparations. It has high nutri-

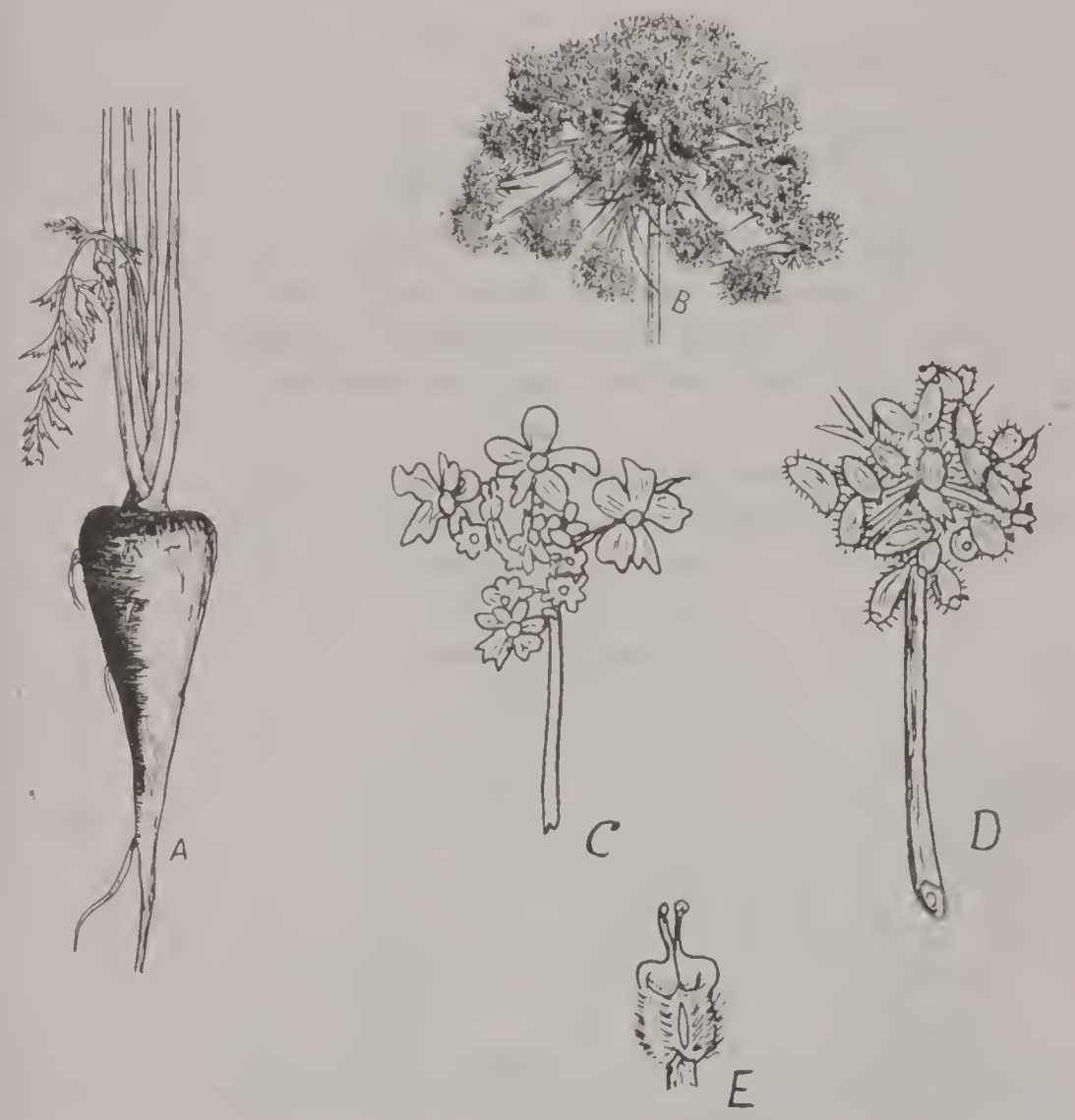

Fig. 46—**CARROT**

A. A Carrot plant showing the conical primary root with secondary roots and a leaf blade. **B.** Inflorescence. **C.** Umblet.. **D.** Fruit bearing umblet. **E.** A single fruit.

tive value with an excellent source of vitamin A and a good source of vitamins B, C and G (B_2). It is said to be a native of Europe and adjoining portions of Asia and is widely cultivated as a winter vegetable in India as the temperature requirement of the crop is only 60°—70°F. For the best development of the crop, it needs deep, loose, sandy loams or loams with a slightly acid reaction.

BOTANICAL DESCRIPTION

Habit: A bristly biennial plant, branching from the base, scabrous.

Root: Tap-root, the main root modified into a food storing organ of conical shape, soft and edible and red-coloured.

Anatomy of carrot root: The transverse section of a carrot root shows the following regions:

(a) *Outer core*: Consists of a thin periderm, a layer of cork cells and a band of secondary phloem.

(b) *Inner core*: Consists of secondary xylem and pith.

The outer core mainly stores sugar and hence a high-quality carrot is judged from a relatively large outer core.

Stem: Herbaceous, erect, hollow, branched and practically with no smell.

Leaf: Heteromorphic, compound, triangular to oblong in outline, 2-3 pinnatisect into oblong-lanceolate, incised-dentate segments and those of the upper leaves linear-lanceolate.

Inflorescence: Compound umbel with numerous rays, bracts of the involucre 3-fid or pinnate, or the involucel linear, white margined, entire or 2—3 fid.

Flower: Mostly white but sometimes bluish or even pale yellow, some of the marginal flowers larger.

Calyx: Sepals (5), gamosepalous, calyx tube with 5 small teeth.

Corolla: Petals 5, obovate, emarginate, outer radiating.

Androecium: Stamens 5, free, alternating with petals.

Gynoecium: Carpels (2), syncarpous, ovary inferior, bilocular, placed anterio-posteriorly; placentation axile; styles and stigmas 2; stigmas surrounded by a honey-disc (*stylopodium*).

Floral Formula: $\oplus$ or $\dagger$ $\varnothing$ $K_{(5)}\ C_5\ A_5\ \underline{G}_{(2)}$

Pollination: Entomophilous.

Fruit and Seed: Schizocarp, small, greenish or brownish, elliptic, terete, dorsally compressed a little and ridged, bristly, aromatic and one-seeded. The seed is very small, dry, indehiscent.

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Genus: **Foeniculum**

The genus Foeniculum includes 4 species and is found commonly in the Mediterranean climates and in Europe. These are tall glabrous biennial or perennial herbs, sometimes annual, with 2–4 pinnate leaves whose ultimate segments are linear or filiform. Inflorescence is an umbel usually with no bracts and bracteoles or when present may be few, small and linear. The calyx tube contains no teeth and the petals are yellow, broadish and emarginate. The fruit is oblong or ellipsoidal with prominent subequal ridges and one oil canal; carpophore bipartite. Seeds are somewhat dorsally compressed, inner face slightly concave.

Feoniculum capillaceum Gilb.

(*F. vulgare* Gaertn)

Hindi: SAUNF *English*: Fennel

Fennel is a cultivated crop or sometimes grows as weed. It is apparently a native of South Europe, but now is diffused over temperate and subtropical regions of the world.

BOTANICAL DESCRIPTION

Habit: The stock is perennial but usually of short duration, cultivated as an annual or biennial for its aromatic seeds and leaves.

Root: Branched tap root.

Stem: Erect (3–5 ft.), branched, glabrous.

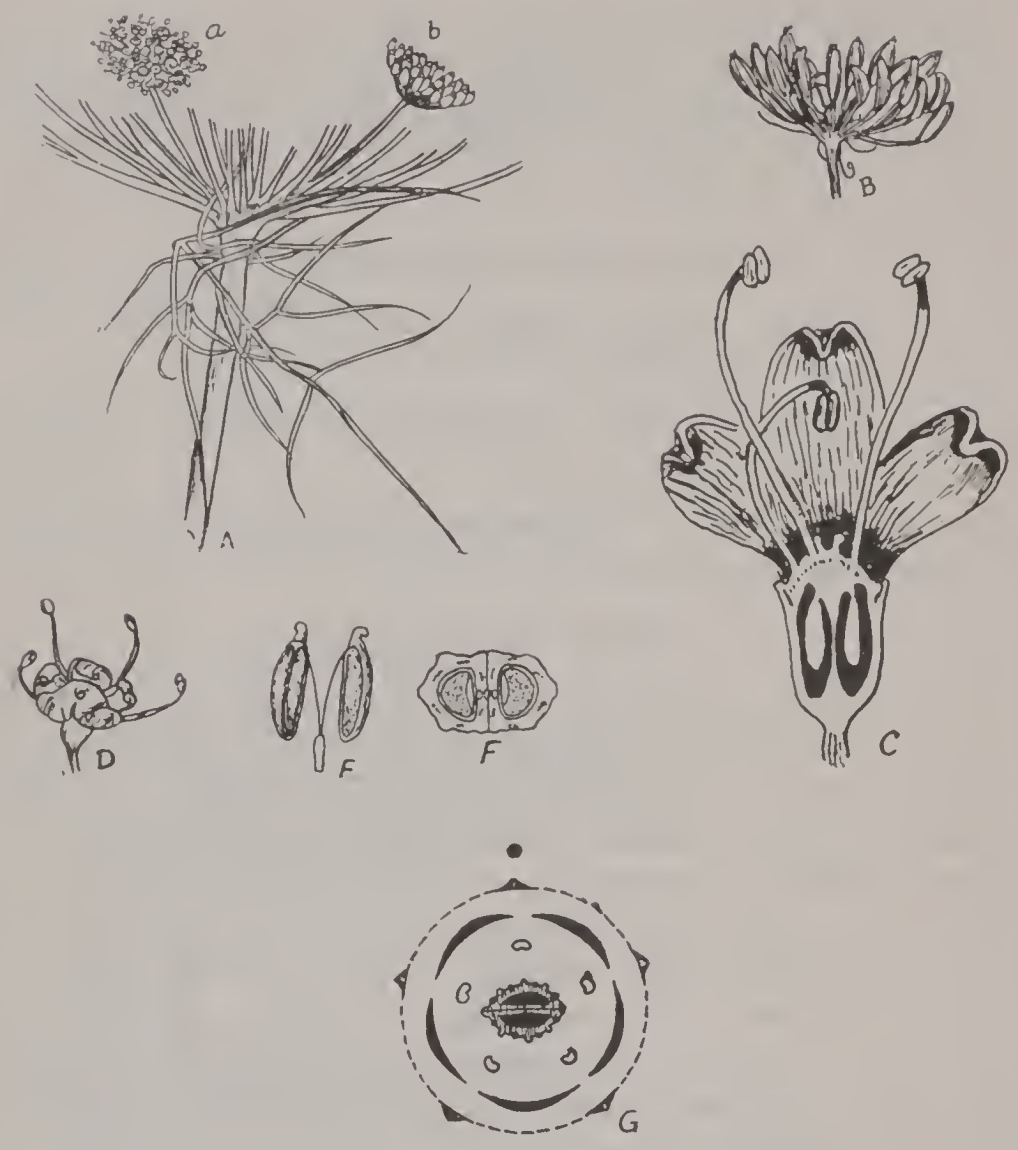

Fig. 47—**FENNEL**

A. Inflorescence with a few leaves showing two umblets; (a) flowers; (b) fruits. **B.** An umblet bearing fruits. **C.** Longitudinal section of flower. **D.** Stamens with epigynous disc. **E.** Fruit. **F.** Cross section of fruit. **G.** Floral diagram.

Leaf: 3–4 pinnate, with very narrow, linear, subulate, thread-like segments. The leaves are stiff in wild species or when grown under dry conditions. Petioles broad and clasping.

Inflorescence: Umbels with 15–20 or more rays, more or less glaucous.

Floral characters similar as described in the genus and family descriptions.

Floral Formula: ⊕ or † ☿ $K_{(5)}\ C_5\ A_5\ \underline{G}_{(2)}$

Fruit: About 6 mm. long, vittae very conspicuous.

CHAPTER XII

Order: CONVOLVULALES

The characters of the order Convolvulales are similar to its single family Convolvulaceae, as described by Rendle. Engler and Diels have recognised the family Convolvulaceae to be under the suborder Convolvulineae and the order Tubiflorae.

According to Rendle both Convolvulales and Tubiflorae come under the group Tetracyclicae and the subgroup Superae and thus possess some common characters. The flowers are regular or zygomorphic, usually gamopetalous (with a few exceptions), epipetalous, characterised by the floral parts usually in four isomerous whorls with a tendency in the decrease of the number of carpels and a superior ovary. The differentiating features between Convolvulales and Tubiflorae are that the former is regular with generally isomerous stamens and the latter is regular or zygomorphic with reduction in the number of stamens.

Family: CONVOLVULACEAE

(Morning glory family)

The family Convolvulaceae includes about 50 genera and 1200 species (about 177 species represented in India). They are widely distributed but commonly found in the warmer parts of the world in the tropical, subtropical and temperate regions. Most of them are mesophytes but many are aquatics and some are thorny xerophytes. Others again are provided with tuberous underground portions (*Ipomea*) or are notorious total parasites (*Cuscuta*).

The distinguishing features of the family are the milky sap or latex present in the vegetative tissues, the presence of bicollateral vascular strands, the plaited (folded) corolla, the intrastaminal disc, the erect sessile ovules with axile placentation and the folded cotyledons.

Familiar Examples:

Sweet potato or SHAKAR-KAND (*Ipomea batatas*), water bind weed (*I. reptans*), morning glory (*I. purpurea*), railway

creeper (*I. palmata*), moon flower (*I. grandiflora*), Bind weed or HIRANKHURI (*Convolvulus arvensis*), dodder or AKASH-BEL (*Cuscuta reflexa*).

FLORAL CHARACTERS

Inflorescence: An axillary dichasium (racemose or paniculate) or solitary and axillary, the peduncle jointed.

Flower: Often large, many have extrafloral nectaries on petiole, pedicellate, complete, bisexual (rarely unisexual by abortion and the plants then dioecious), pentamerous (except gynoecium), regular, hypogynous; bracteolate, bracteoles usually in a pair and develope at a distance below the flower, sometimes large and enclose the calyx or may form an involucre.

Calyx: Sepals 5, generally free (rarely fused), valvate or imbricate, the two or three outer often larger than the inner, persistent.

Corolla: Petals (5), gamopetalous; corolla tube is generally funnel-shaped or salver form, more rarely campanulate or tubular with the margin entire or slightly 5-lobed and sometimes with appendages within (*Cuscuta*); aestivation induplicate valvate or twisted in the bud.

Androecium: Stamens 5, free, epipetalous inserted at the base of the corolla tube, alternate with the corolla lobes; filaments slender and varied in length; anthers two-celled, dorsifixed, ovate to linear, generally introrse, dehiscing longitudinally; intrastaminal disc generally present and ring-shaped or cup-shaped.

Gynoecium: Pistil 1; carpels (2), rarely (3—5) carpelled, syncarpous, with a broad base on a honey secreting hypogynous disc; ovary superior, typically bilocular (sometimes 1—4 locules, the latter by false septa); axile placentation; ovules 1—2 in each locule (rarely 1 or 4), erect, anatropous, sessile, springing from the inner angle of each chamber, the micropyle pointing downwards; style generally simple, filiform or more or less bipartite (sometimes two); stigma terminal and capitate or two distinct stigmas of various shapes.

Floral Formula: $\oplus \; \mathfrak{P} \; K_5 \; \overbrace{C_{(5)}} \; A_5 \; G_{(2)}$

Pollination: Natural crossing readily occurs through entomophily. Insects are attracted by the showy flowers and

nectaries. Nectar-seeking birds may also visit certain of the species. Sometimes the flowers are cleistogamous.

Fruit: Generally a capsule with loculicidal dehiscence (rarely indehiscent and fleshy), berry or nut-like.

Seed: As many as the ovules or fewer, as usually in the indehiscent fruit; smooth or hairy, exalbuminous, embryo large and characteristically folded or bent, surrounded by a hard cartilaginous endosperm, cotyledons often emarginate or bilobed and the radicle directed towards the hilum.

VEGETATIVE CHARACTERS

Habit: Annual or perennial herbs, often twiner or climber, more rarely shrubby, very rarely tree-like. Some genera are yellow almost leafless twining total parasites (*Cuscuta*).

Germination: Commonly epigeal.

Root: Tap roots with branches, sometimes the roots become tuberous and act as storage organs (*I. batatas*).

Stem: Weak, twining in most cases; herbaceous (rarely woody); glabrous or hairy; sap usually milky; often turf-forming or thorny when shrubby; sometimes rhizomatous.

Leaf: Simple, alternate, exstipulate, often with accessory axillary buds. Margins may be entire, lobed or pinnately dissected in some cases, rarely compound; sometimes reduced to small scaly structures devoid of chlorophyll (*Cuscuta*).

Economic Importance:

One of the best known economic products is the Sweet Potato, which consists of the tubers of *I. batatas,* a plant widely cultivated in tropical countries. Several species produce handsome flowers and are widely used as ornamentals (morning glory, cypress vine, moon flower etc.). A few are well known for their medicinal values (e.g., *I. purga* is a powerful purgative).

Genus: **Ipomea**

Ipomea is the most highly developed genus of the family Convolvulaceae including the maximum number of species (400 sp.) and is mainly found in the tropical and temperate regions. They include herbs (rarely shrubs), twiners and climbers with prostrate, rarely erect or suberect habit. The

roots are tap or adventitious roots and the lateral roots are sometimes modified as tubers. Leaves alternate, simple, entire or lobed, sometimes pinnately dissected or palmately compound, acuminate, rather coriaceous. Flowers often large, showy, whitish or purplish, axillary (rarely paniculate), solitary or in cymes (which may be reduced to a single flower), with pentamerous perianth whorls and stamens. Sepals 5, equal or unequal, imbricate, often enlarged in fruit. Petals (5), campanulate or funnel-shaped, entire or slightly lobed; limb plicate; bands usually defined by two prominent lines. Stamens 5, usually included; filaments filiform or dilated below, often unequal, hairy, smooth or bearded; anthers straight or contorted; pollen grains echinulate (a spherical form with a spiny extine—also called spinulose). Ovary usually two-celled, rarely 3 or 4-celled; ovules 4, rarely 6; style filiform; stigma capitate with 2 lobes, globose. Capsule usually 4-valved (may be 4-6), rarely indehiscent. Seeds usually 4 or 6 (rarely solitary), glabrous, bearded or uniformly velvety or wooly, cotyledons crumpled or often 2-lobed.

Impoea batatas Lam. or Poir

Hindi: SHAKAR-KAND-ALU *or* MITHA-ALU *English*: Sweet potato

Sweet potato is the only species of the family Convolvulaceae which is important for its food value. It is originally a native of America but now is widely cultivated in many parts of the world, mainly in the tropical and temperae regions (Brazil, southern states of U. S. A., Malaya, East Indies, West Indies, China, India and parts of New Zealand and Australia). It It is grown for its edible tuberous roots, rich in starch and sugar and consumed after boiling or roasting. In some parts it forms a subsidiary food crop capable of replacing cereals to some extent while in others it is an important vegetable. It likes a warm climate and can be grown purely as a rainfed crop in semiarid regions. It is considered to be the most drought resistant vegetable, but a moderate rainfall or a few timely irrigations during the growing season is, however, desirable for a profitable return. It does not thrive above 4000 ft. or in regions having less than 4 months frost-free period. It

grows most successfully in deep, loamy and sandy soils, which are friable and is ready to be dug up within 100—165 days. Red and white varieties are commonly recognised and they differ in shape, size, colour, cooking quality and yield of tubers.

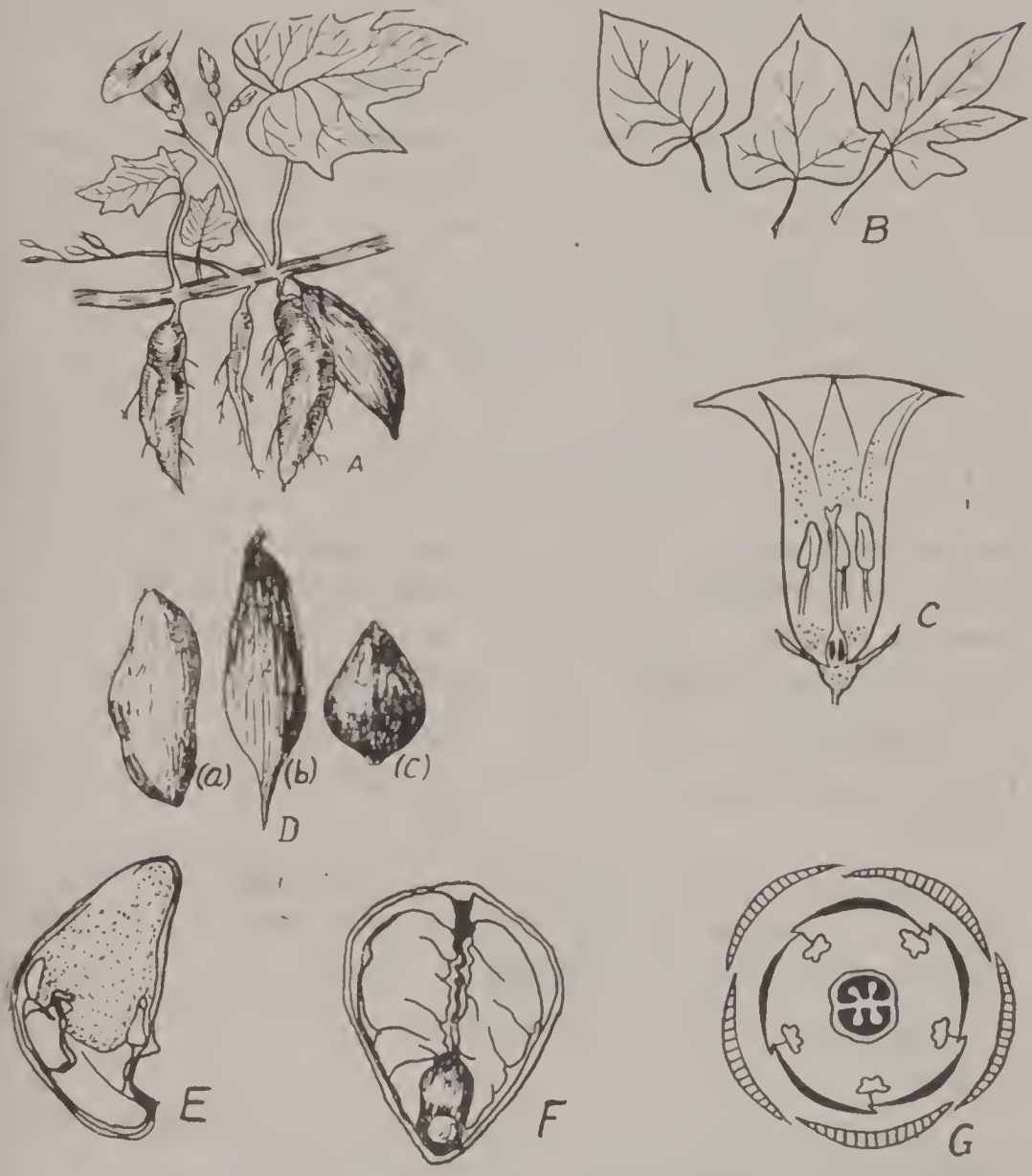

Fig. 48—**SWEET POTATO**

A. The plant. **B.** Various forms of leaves. **C.** Flower-section. **D.** Root shapes. **E. F.** Seed dissectd.e **G.** Floral diagram of Ipomea.

BOTANICAL DESCRIPTION

Habit: It is a vine-like, prostrate annual herb with milky juice.

Root: When grown from seed it possesses a tap root system and the lateral roots are modified and become fleshy that being the sweet potato, but if grown from fleshy roots, stem cuttings or young sprouts known as *"draws"* or *"sets"*, the root system becomes adventitious fibrous, some of those thicken to form the sweet potato. These fleshy roots or sweet potatoes vary widely in shape, size and smoothness of the skin.

Stem: Weak, herbaceous, trailing or twining, usually hairy on the younger parts or may be glabrous throughout. In prostrate vines, adventitious roots occur at each node.

Leaf: Vary widely in shape and form and they may be cordate, hastate, slightly to deeply lobed or cut. The apex and the lobes are acute or obtuse, the base is cordate to truncate; and in some instances, the midrib of the leaf or leaflet is prolonged beyond the blade to form a short awn-like structure. Generally, the first few leaves are cordate, while those formed later may be hastate, cut or lobed. Arranged spirally with 2/5 phyllotaxy and the venation is palmate. Petiole possesses petiolar nectaries on either side just below the base. Leaves possess glandular hairs on both surfaces.

Inflorescence: The plant bears very few flowers and fruits; the flowers are borne on a long peduncle in axillary cymose.

Flower: Upward, purple in colour, bisexual, complete, regular, hypogynous, funnel-shaped with pentamerous symmetry but reduction in the number of carpels.

Calyx: Sepals 5, polypetalous, elliptic, shortly acute, glabrous.

Corolla: Petals (5), gamopetalous, widely tubular, funnel shaped with purple throat and white margin.

Androecium: Stamens 5, free, epipetalous, included.

Gynoecium: Carpels (2); syncarpous; ovary bilocular but appears 4-locular due to the formation of a false septum in each locule, superior, with one anatropous ovule in each locule which developes at the inner angle.

Floral Formula: $\oplus \; \varnothing \; K_5 \; \overbrace{C_{(5)} \; A_5} \; \underline{G_{(2)}}$

Pollination: Natural crossing occurs readily through the agency of insects.

Fruit: A globose or ovoid capsule, brownish in colour, four-valved due to the intrusion of false septa with one seed in each locule.

Seed: Usually the seeds are not viable, but the plants profusely flower in some parts of the world and produce abundant viable seeds. Seeds are small, black, glabrous, somewhat flattened, with one surface angular and the other roughly convex; seed coat rough and corneous in texture, and impervious to water; cotyledons folded. Endospermic—a pulpy endosperm invests the cotyledons.

Germination: Epigeal. Seeds germinate rapidly and establish themselves within a fortnight or so. The cotyledons, appearing as first green leaves, are deeply bilobed and the lobes are obtuse or subacute. Scarified seeds are found to germinate more readily.

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Ipomea reptans Poir.

Hindi: KALMI *English*. Water bind weed

These are creeping prostrate or floating aquatic plants, abundantly found in the rainy seasons in ponds and ditches;

sometimes cultivated as vegetable; contains milky juice which after drying is used as a purgative; a plant perennial in habit.

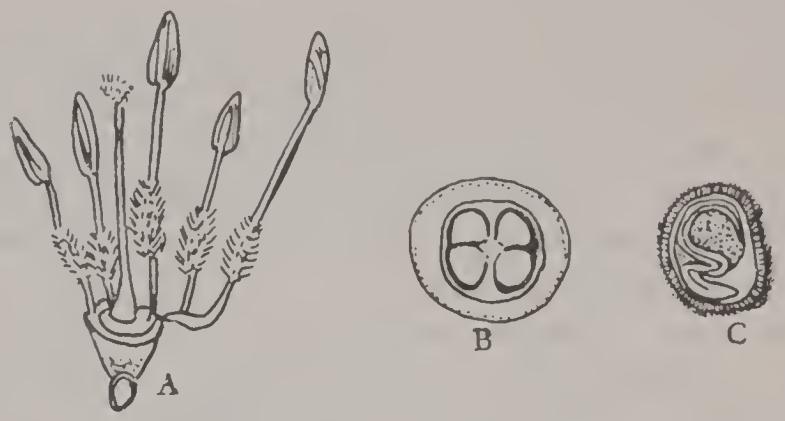


Fig. 49—**WATER BIND WEED**

A. Dissected flower showing unequal stamens and pistil. **B.** Section of ovary showing axile placentation. **C.** Seed of an Ipomea species cut lengthwise showing folded cotyledon and endosperm.

BOTANICAL DESCRIPTION

Habit: Aquatic herb with latex.

Root: Adventitious fibrous, coming out from the node of the stem.

Stem: Weak, trailing or floating, sometimes to a great length, glabrous, cylindrical, hollow, nodes semisolid with branches.

Leaf: Alternate, phyllotaxy 1/2 or 2/5; exstipulate; petiolate, petiole long, cylindrical; leaf shape saggitate, hastate or cordate; margin entire or more or less angular lobed, apex acute; venation reticulate unicostate; surface glabrous.

Inflorescence: Axillary, solitary or in bunches of 2-3 flowers borne on a peduncle.

Flower: Pale rose-coloured; pedicellate, pedicel long, cylindrical, smooth; bracts inconspicuous; bracteole 1, minute; complete, bisexual, actinomorphic and hypogynous.

Calyx: Sepals 5, free, subequal, ovate-obtuse, apex acute, margin entire, surface glabrous, aestivation imbricate, green coloured with border and tip reddish.

Corolla: Petals (5), united to form a single limb which is to some extent 5-lobed; calyxtube campanulate with bands

usually defined by two prominent lines, aestivation valvate; fragile, glabrous, whitish or pale purple in colour with lower inner half reddish, slightly hairy at the base.

Androecium: Stamens 5, free, inserted, epipetalous, filaments unequal, dilated below, in the shorter stamens filaments as long as anthers, hairy at the base; anthers basifixed, 2-celled, straight, dehiscing longitudinally.

Gynoecium: Carpels (2), syncarpous, ovary superior, yellowish, having a round disc at the base; style filiform, simple; stigma capitate having two lobes; ovary 2–4 celled, each cell having 2–4 ovules; placentation axile; ovules anatropous.

Floral formula: ⊕ ☿ $K_5 \overbrace{C_{(5)}}\ A_5\ \underline{G_{(2)}}$

Fruit: Capsule; 4–6 valved, rarely indehiscent, with persistent calyx; glabrous.

Seed: Usually 4-6, small, mostly minutely hairy or nearly glabrous, bearded, micropyle deeply invaginated so that a tubular cavity is formed above the hilum and the inner portion of the seed coat is infolded to a great extent forming two chambers at the apical end.

Germination: Epigeal.

Genus: **Cuscuta**

The genus Cuscuta includes parasitic annuals which are leafless and rootless, yellow or reddish, with twining habits, twining over the host plant. They are found both in the tropical and temperate regions of the world and comprise the third largest genus of the family Convolvulaceae with about 120 species.

The roots are adventitious parasitic (haustoria); stem yellow, slender and filiform and leaves when present are minute, scaly and devoid of chlorophyll. The flowers are very small, white or rose coloured, sessile or pedicellate, solitary or in lateral fascicles or short racemes and usually with small bracts (sometimes absent). The calyx tube usually possesses 5 (rarely 4) deeply divided segments, sometimes free, subequal. The corolla tube is campanulate, ovoid or globose, usually with fimbriate or lobed scales near the base of the corolla or below the stamens within with 5 or 4 short lobes which are imbricate in bud. Stamens 5 or 4, inserted in or below the throat of

the corolla tube; filaments short, obtuse, partially exserted. Ovary bicarpellary, syncarpous and is perfectly or imperfectly 2-celled; ovules 2 in each cell. The fruit is a capsule; globose or ovoid; dry or succulent; 2 to 4 seeded and opening by a lid. Seeds are glabrous, with fleshy albumen, slender spiral embryo and obscure cotyledons.

C. monogyna, C. epithymum, C. reflexa, C. trifolii, C. europaea, and *C. epilinum* are some of the most notorious species of the genus.

Cuscuta reflexa Roxb.

Hindi: AKASH-BEL *English*: Dodder

It is a notorious total parasite destructive to hedges, shrubs and many fruit trees, often forming a dense mass and covering the host plant with a tangle of bright orange threads. Sometimes it is used as veterinary medicine by Indians for poultice on sprains.

BOTANICAL DESCRIPTION

Habit: A yellowish green, glabrous, twining vine: total parasite, leafless and herbaceous.

Root: Normal roots absent in mature plant but present only at the germination stage; it has adventitious parasitic roots or *haustoria* which penetrate the tissue of the host and rob its food.

Stem: Long, slender, yellow, twining closely with the host plant, sending haustoria at different places, branched, sometimes slightly irregularly pigmented.

Leaf: Absent, rudimentary or scaly.

Inflorescence: Solitary or in irregular cymose clusters, sometimes racemed.

Flower: Minute, white, waxy; pedicellate, pedicel short; bracteate, bracts minute, ovate to ovate-oblong, obtuse, narrower and smaller upwards; regular, complete, bisexual, hypogynous, pentamerous (except gynoecium). Plowering occurs during cold season.

Calyx: Sepals (5), gamosepalous but deeply 5-partite, aestivation valvate, whitish, sometimes pigmented.

Corolla: Petals 5, gamopetalous, corolla tube subcampanulate, slightly reflexed at the tip; aestivation imbricate; petals white with pigmented base, deciduous, prominent fimbriate incurved scales present inside the corolla tube, connate at the base near the bottom.

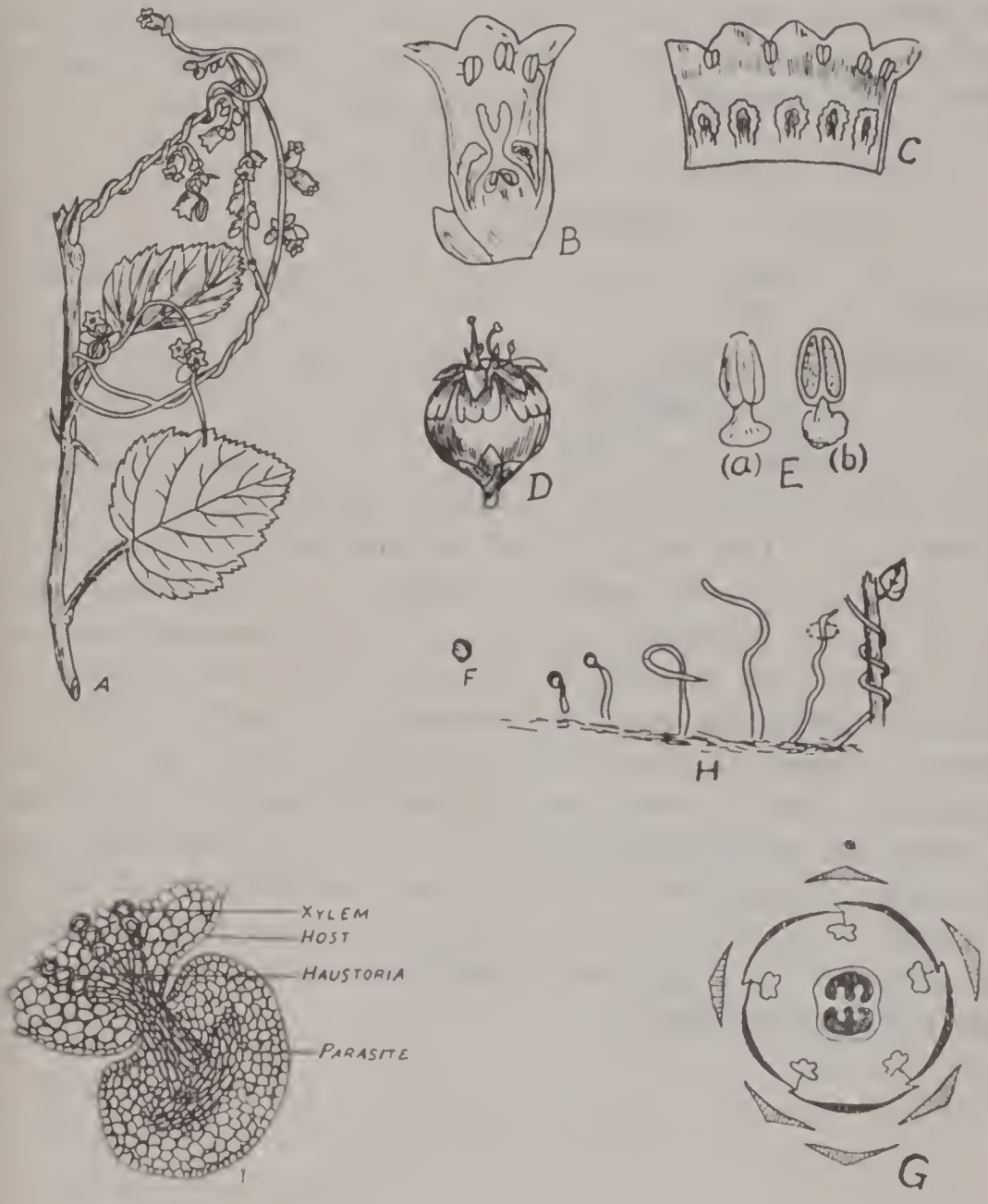


Fig. 50—**DODDER**

A. Dodder plant on its host. **B.** Flower cut open. **C.** Part of corolla spread out. **D.** Fruit covered above by withered flower. **E.** Stamen. **F.** Seed. **G.** Floral diagram. **H.** Stages of germination of dodded seed. **I.** Penetration of haustoria.

Androecium: Stamens 5, inserted at the throat of the corolla tube and alternating with the lobes; filaments minute; anthers 2-celled, introrse, basifixed, dehiscence longitudinal, yellow in colour.

Gynoecium: Carpels (2), syncarpous; ovary superior, mounted on a coloured disc, more or less completely 2-celled but often appears to be 4-locular due to the formation of false septa; style single, short; stigmas 2, flat at the base; ovules 2 in each cell, anatropous, placentation axile.

Floral formula: ⊕ ☿ Br_1 $K_{(5)}$ $\overbrace{C_{(5)}}$ $\overbrace{A_5}$ $\underline{G_{(2)}}$

Pollination: Autogamous.

Fruit: Capsule, globose, ovoid, dehiscing at the base and opening by a lid.

Seed: Albuminous, embryo thread like and very much twisted, cotyledons obscure.

Germination: The seeds ripen in late summer or autumn. The seed germinates on the ground in spring and a short root is developed. This enters the soil and the young seedling is able to lead an independent existence only as long as the stored food in the seed is available. The stem is thin, elongated and extremely sensitive to contact. The tip of the stem exhibits a peculiar, irregular, rotatory movement known as *'nutation'*. When it comes in contact with another plant, the tip rubs against it and the stem curves round the support. After the parasite has thus attached itself to its host, the small root dies out and the parasite is left completely on the host to lead a parasitic life. In case the young dodder vine does not come in contact with a congenial host plant around which it can twine, it soon perishes.

CHAPTER XIII

Order: TUBIFLORAE

Tubiflorae is a large order of primarily herbaceous plants, but woody plants also occur with alternate or opposite generally simple leaves. It includes 4 suborders and 17 families.

The order is characterised by the bisexual, regular or more often zygomorphic, hypogynous (rarely epigynous) and tetracylic flowers. Stamens generally four or two by reduction. Ovary usually bicarpellary (rarely 3–5); ovules many to few in each cell with typically marginal placentation and with a single integument.

Solanineae is an important suborder under Tubiflorae comprising of 12 families. The flowers of Solanineae are usually medianly zygomorphic, sometimes regular. Stamens in equal number as perianth with 4 or 2 fertile stamens. Ovary bicarpellary with usually indefinite ovules. Fruit usually a capsule.

Family: **Solanaceae**

(Potato family)

The family Solanaceae comprises of 85 genera, most of which are confined between tropical and temperate regions, a few are seen in the countries of Europe but a very large number occurs in South and Central America. It contains about 2000 species out of which about 85 species are found in India.

The most distinguishing features of the family are pentamerous, bisexual, regular and hypogynous flowers with fused calyx and corolla; stamens epipetalous and sometimes syngenesious; syncarpous bicarpellary pistil with oblique ovary having axile placentation; fruit a berry or capsule.

Familiar Examples:

Potato or ALU (*Solanum tuberosum*), brinjal or BHANTA or BAIGAN (*S. melongana*), black nightshade or MAKO (*S. nigrum*), chilli or red pepper or LAL MIRCH (*Capsicum frutescens*), tomato or TAMATAR (*Lycopersicum esculentum*), gooseberry or RASPHBHARI (*Physalis peruviana*), tobacco or

TAMBACOO (*Nicotiana tabacum* and *N. rustica*), thorn apple or DHATURA (*Datura fastuosa*), queen of the night shade (*Cestrum*) and Petunia (garden herb).

FLORAL CHARACTERS

Inflorescence: Terminal on the main lateral axes, solitary or in cymes or combination of cymes, sometimes helicoid.

Flower: Usually pedicellate; actinomorphic, slightly zygomorphic; hypogynous, complete, bisexual, in pentamerous symmetry with reduction in the number of carpels.

Calyx: Sepals (5), gamosepalous, calyx tube 5-lobed (sometimes 4–6-lobed), aestivation valvate or imbricate, persistent, often enlarging with the fruit, inferior.

Corolla: Petals (5), gamopetalous, corolla tube rotate to tubular or campanulate with typically 5 lobes (sometimes 4–7 lobed), rarely bilabiate; aestivation valvate, twisted or even imbricate; ptyxis various, generally plicate, sometimes also convolute; hypogynous.

Androecium: Stamens primitively 5, free, epipetalous, inserted and alternating with corolla lobes; in zygomorphic flowers often unequal, sometimes one is rudimentary; anthers apparently connate, and often connivent round the style, 2-celled, dehiscing by longitudinal slits or pores; hypogynous disc usually present and apparent.

Gynoecium: Pistil 1; carpels (2), syncarpous; ovary superior, bilocular (may be multilocular by false septation but rarely unilocular), carpels generally obliquely placed and not in a median plane; ovules generally numerous on swollen axile placentae, anatropous or slightly amphitropous; style 1, simple; stigma bilobed. Honey secreting disc generally present below the ovary.

Floral Formula: $\oplus\ \varnothing\ K_{(5)}\ \overbrace{C_{(5)}\ A_5}\ \underline{G_{(2)}}$

Pollination: Entomophilous, performed by long tongued insects due to the tubular shape of corolla and location of nectaries at the base of the stamens.

Fruit: A berry or capsule with many seeds, sometimes septicidal.

Seed: Smooth with a pitted testa; embryo bent or straight, embedded in the fleshy and semitransparent endosperm.

VEGETATIVE CHARACTERS

Habit: Herbs, shrubs or small trees, often lianous or creeping; usually mesophytes.

Germination: Epigeal; some are propagated vegetatively (potato).

Root: Tap root with branching.

Stem: Herbaceous, strong and erect or weak and creeping or lianous, branched, hairy or prickly, sometimes modified as underground storage organs (tubers). The notable anatomical feature is the presence of bicollateral vascular strands.

Leaf: Various, generally alternate, rarely opposite or verticillate. In the apical regions where the flowers are borne, the leaves may be found to be in pairs. They are exstipulate and in most cases simple, entire or variously dissected or pinnately compound.

Economic Importance:

The Solanaceae is a family of considerable economic importance including such food plants (vegetables and edible fruits) as potato, tomato, brinjal, chilli or red pepper and goose-berry; such fumitory and narcotics as tobacco (also useful for its medicinal and insecticidal properties); such important medicinal plants as balladonna, atropine, thorn apple, henbane etc.. and many commonly grown ornamentals as Petunia, Cestrum and others.

Genus: **Solanum**

The genus Solanum is one of the largest genera of flowering plants including about 1225 species, mostly found in the hotter parts of the globe and most numerous in America. They are of very various habits, herbs, shrubs or rarely small trees, spinuous or unarmed. The leaves are alternate or subopposite in equal pairs, entire lobed or pinnatifid. Inflorescence is cymose, compact racemose, umbellate or rarely paniculate; lateral, lying opposite the leaves or terminal. Sometimes these are extra-axillary, owing to the union of the flower shoot for some distance above the position of its bract with the axis of the next higher degree, the flower shoot thus appearing to spring from the middle of an internode. Calyx tube campanulate or rotate, usually 5-lobed, rarely 4-lobed, or subentire,

unaltered or enlarged in fruit. Corolla limb generally 5-lobed, short, rotate, rarely campanulate and plaited in bud. Stamens 5 (rarely 4–6) inserted in the corolla throat and all fertile; filaments short, equal or unequal in length; anthers oblong, narrowed upwards, connivent into a cone round the style in the centre of the flower and dehisce by apical pores, more rarely by a short terminal slit or longitudinally also. Ovary 2 celled, rarely (in cultivated forms) 3-4 celled, many ovuled; style columnar; stigma small and terminal. The fruit is a berry, globose or elongate, with persistent calyx. Seeds are numerous, discoid; embryo peripheric, curved through more than a semicircle.

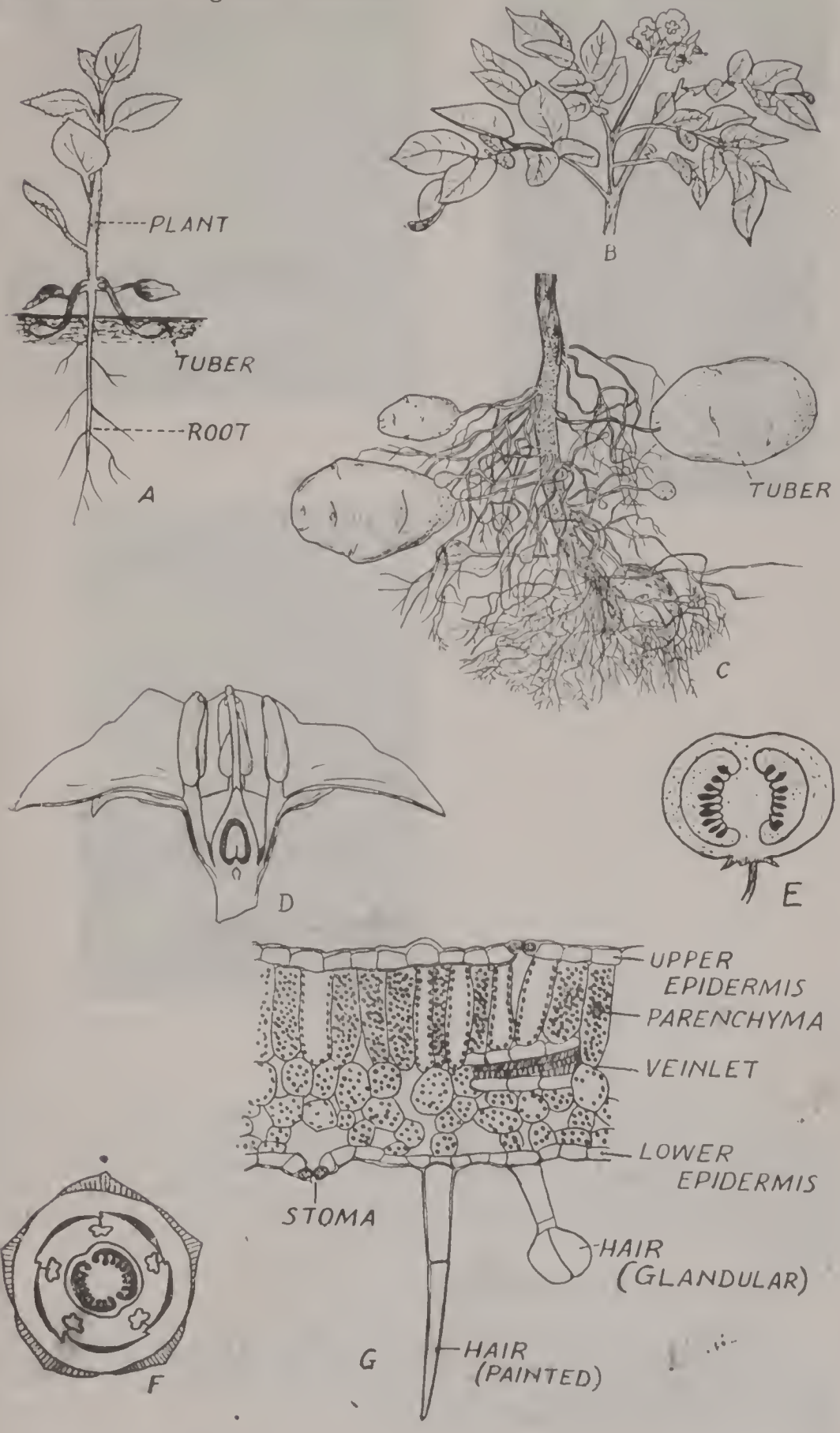
The most important species of the genus is *S. tuberosum* Linn. (potato) of great commercial value. *S. melongena* Linn. (brinjal) is another important cultivated species grown as vegetable.

Solanum tuberosum Linn.

Hindi: ALU *English*: Potato

Potato (*S. tuberosum*) is one of the most popularly cultivated vegetable of great commercial importance. Although originally discovered in S. America (Peru-Bolivia region) but is now cultivated in many parts of the world for its edible tubers and propagated from its cuttings. As an article of diet, potato ranks very high, second only to the cereal grains. Its carbohydrate content is the same as that of wheat while the protein content is lower, but its quality is very high. It is rich in vitamins C and B_1. Potato when combined with fats, and supplemented with a little more protein, forms an ideal diet like the cereals. Apart from its dietary use, potato starch (*farina*) is used in the textile industry for sizing yarn and also for laundering purposes. Its other industrial uses are preparation of bear, starch, dextrine, glucose, power alcohol and similar other products. The crop is more suited to the colder latitudes, temperate zone and the cold months of the sub-tropical climates. It can stand wide ranges of temperature and elevation but cannot stand high rainfall. In India, nearly $6\frac{1}{2}$ million acres of land is annually sown for potato, of which U.P. has the highest acreage and then in order comes Bihar and West Bengal, where it is principally grown on the

hills of the submontane tracts but considerable areas in the plains also during cold weather.



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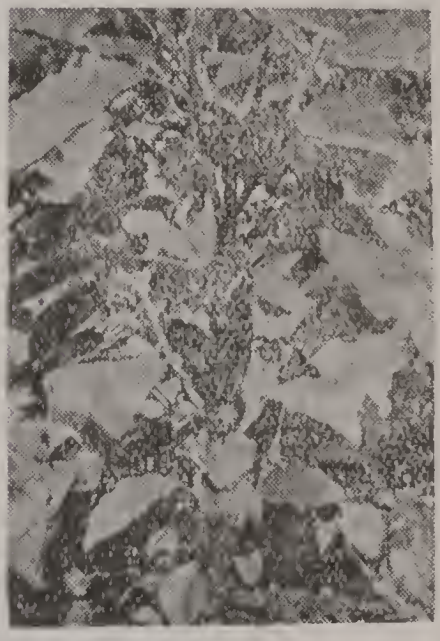

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Fig. 51—**POTATO**

A. A growing plant. **B.** Portion of a plant with leaves and flowers. **C.** Tubers of potato. **D.** Median longitudinal section of flower. **E.** Fruit (berry)—longitudinal section. **F.** Floral diagram. **G.** Transverse section of potato leaf. **H.** The potato plant with tubers. **I.** A cultivated field of potato. **J.** A brinjal plant.

BOTANICAL DESCRIPTION

Habit: A cultivated annual herb, erect, procumbent or prostrate but potentially a perennial, perpetuated by means of its tubers or underground stems.

Root: A true potato seedling developed from seed produces a delicate tap root, confined chiefly in the upper layer of the soil, fibrous, much branched and more pronounced than in most crops. The primary root and its branches are distinct from the tuberbearing rhizomes, but from the nodes of all the stems below ground adventitious roots arise in abundance. The tubers do not bear roots. In plants grown from tubers, however, the roots are all adventitious, fibrous and much branched.

Stem: Consists of aerial and underground stems. Aerial stem—herbaceous, may stand erect or become procumbent or even prostrate; round or roughly triangular at maturity and angles winged; pubescent or glabrous; green or purplish—the anthocyanin pigment in the stem is usually present when the stem is coloured; internodes hollow at maturity except at nodes and a few exceptional varieties; branched, branches long and smooth. Underground stem—rhizomatus, the horizontal branches are developed in the axil of scaly leaf of the stem below ground. The tips of rhizome swell to form *"tubers"*.

The causes of tuberization is not well understood—in general, it is found that darkness, low temperature, and short days favour the development of potato tubers. Many of the present-day authorities are of the opinion that potato tuber is in reality a gall or tumour, initiated by some fungal organism.

The tuber is the condensed apical portion of the rhizome, rich in starch (10–26% depending upon variety) and proteids (2%). That these tubers are stem structures is shown by their origin and their possession of buds—the *"eyes"*. Each eye is a small bud in the axil of an aborted scaly leaf (represented by a semicircular rim) which can be considered to be a lateral branch with undeveloped internode. The number of eyes are greater towards the apical end and have a prominent terminal bud. The eyes are arranged in a spiral phyllotaxy. The apical end is called *"crown end"* and the basal is called *"stem end"*. The terminal bud which sprouts first being most vigorous is known as *"master sprout"*.

When the parent plant dies down after the expiration of the growing season, the tubers become detached, and in the next season they form new plants by the development of the eyes, at the expense of the starch and other reserves stored in the tuber. By heaping earth against the stem, so as to cover

more of the leaf axils, more of the axillary shoots are made to become tuber-bearing; hence the value of ridging potatoes.

Anatomy of the tuber: When a mature tuber is cut, the following zones or layers are easily noticeable:

(a) *Periderm or skin*—This developes after the dying out of the true epidermis of the stolon or rhizome (which originally possesses a true stem structure) and is the outer layer of cortex and underlain by a continuous cork cambium. This offers considerable resistance to infection by micro-organisms. The periderm has a numer of lenticels.

(b) *Cortex*—An outer parenchyma tissue below the periderm.

(c) *Pericycle*—A many-layered ring-like zone lying internal to the cortex.

(d) *Vascular ring*—Consisting of fibro-vascular bundles which are bicollateral and have phloem arranged both to the outside and to the inside of the xylem.

(e) *Medulla*—This is the chief bulk of the potato and includes that part of the tuber which is inside the ring of xylem bundles; it is made of parenchyma with small scattered bundles of phloem. The medulla consists of *internal medulla* with greater percentage of water and *external medulla* with higher starch percentage, darker and denser.

Leaf: Pinnately compound with more or less petioled leaflets; phyllotaxy 1/3; petiole well developed, semicircular, base flattened and sheathing the main stem; terminal leaflet large and obovate; lateral leaflets shortly stalked, both ovated acuminate; arranged in opposite pairs with smaller secondary leaflets in between; leaflets possess acute apex, entire margin and pubescent surface. The foliage has the narcotic smell characteristic of tobacco and tomato. Considerable differences exist in the leaves of different varieties.

Inflorescence: Borne on a primary axis which usually divides into two secondary axes. Occasionally the two axes divide again resulting in a compact racemose type of inflorescence and extra-axillary in origin.

Flower: The flowers seldom form fruit with fertile seeds, perhaps because of the long continued dependence upon vegetative means of reproduction by tubers. The flowers are more or less regular; perfect; purplish to almost whitish in colour

depending on variety; bisexual; pentamerous; pedicellate, hypogynous.

Calyx: Sepals (5), gamosepalous, five partite, lobes linear-lanceolate, green, with valvate aestivation in bud.

Corolla: Petals (5), gamopetalous, 5-lobed, rotate, purplish to almost white coloured, petals linear in shape, margin entire, apex acute, membranous.

Androecium: Stamens 5, epipetalous, filaments short; anthers two-lobed, yellow, basifixed, connivent round the style, forming a cone and dehisce by apical pores or by a short longitudinal slit. Most varieties of potato bear infertile pollens, hence fruits (berries) do not form.

Gynoecium: Carpels (2), syncarpous; ovary superior, bilocular, with many ovules, ovules anatropous; axile placentation; style single, hairy, erect but slightly curbed near the stigma; stigma terminal, sticky, greenish, capitate and almost embedded in the cone of the anthers.

Floral formula: $\oplus \; \varnothing \; K_{(5)} \; \overbrace{C_{(5)} \; A_5} \; \underline{G_{(2)}}$

Pollination: Potato flowers are rarely visited by insects and in some varieties flowers do not open. The flowers are also protogynous by nature, hence self-fertilization is natural to this species.

Causes of Failure to Set Fruits:

Usually three reasons are forwarded for explaining the causes of the failure to set fruits in potato:

(a) Failure due to nonblooming, resulting from flower abcission.

(b) Failure due to pollen sterility.

(c) Failure due to degeneration in the ovules.

In general, the failure to set fruit is attributed to prolonged vegetative reproduction by means of the tubers.

Fruit: A brown or purplish, globular or short ovoid berry (potato-ball), with many seeds attached to a thick axile placenta with green acrid pulp.

Seed: Exalbuminous.

Germination: Epigeal, from the axil of the aerial cotyledons (now functioning as leaves) shoots arise which are posi-

tively geotropic. These shoots soon find their way into the ground and after the growth of 2-3 internodes, their tips are modified into tubers. These tubers remain dormant during the off season but again germinate vegetatively from their eyes in the ensuing growing season.

During the sprouting of potato tubers, the reserved starch is converted into sugar by the enzyme diastase which is then available to the growing shoot in its initial stage, prior to leaf formation.

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Genus: **Lycopersicum**

The genus Lycopersicum includes many familiar garden fruits and vegetables, broadly grouped under *"tomato"*. It circumscribes nearly 10 species, majority of which are the products of South America.

Plants thickly pubescent and straggling. Leaves irregularly or interruptedly pinnate and smelling. Flowers small, yellow, nearly rotate when in full bloom, in short superaxillary racemes; stamens 5, connate about the single style, the anther tips are narrow and sterile and exhibit complete longitudinal dehiscence. Ovary 2-loculed in the non-ameliorated forms, becoming a fleshy many-seeded berry.

L. esculentum Mill and *L. pinpinellifolium* Mill are the two cultivated species of the genus, of which the former is more important with 4-5 botanical varieties.

Lycopersicum esculentum Mill.

Hindi: TAMATAR, *English*: Tomato
BILLAETTE BAIGAN

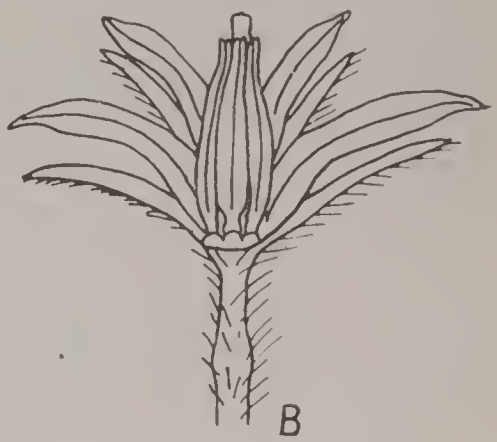
Tomato is an extensively cultivated vegetable grown for its edible fruit which is very high in vitamin contents (A, B, C and G). It is utilized for home, market-garden and canning purposes. This grows favourably in warm season with long growing period in a sunny open place on a great variety of soils. It thrives best in a day temperature of 65°–85°F and is killed by too low temperatures (32°F) or by frost. India grows it during rainy season on the plains.

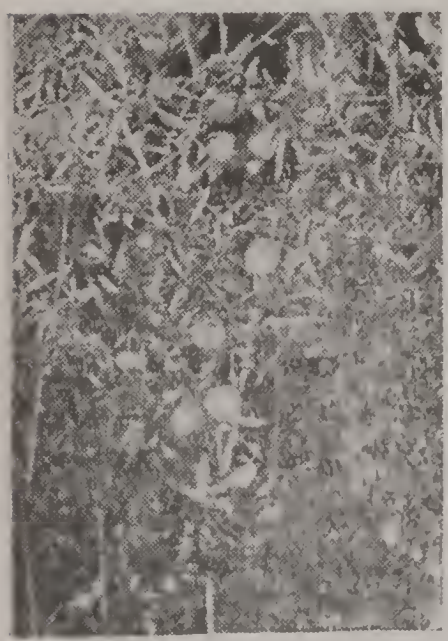
Its original home is South America where the conditions for its best growth is optimum. According to some authorities it is a native of tropical America and the name 'tomati' is only of South American origin from 'zitomate' or 'zitotomate'. Growing of tomato for culinary uses and canning industries has made a rapid stride during the latter half of nineteenth century. Its cultivation in India is more recent and rapidly gaining popularity.

BOTANICAL DESCRIPTION

Habit: A cultivated annual, grown in India generally during the rainy and post-rainy season.

Root: Originally it possesses a tap root system but when transplanted the primary root is injured and a dense fibrous system of lateral and adventitious roots is formed which persist throughout the life of the crop. As the stems easily develop adventitious roots, sometimes they are propagated from cuttings.





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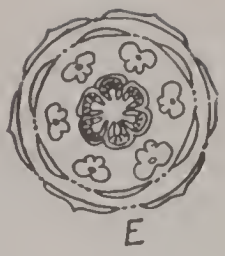

Fig. 52—**TOMATO**

A. A portion of stem bearing flower, fruit and leaves. **B.** Flower cut open. **C.** Pistil. **D.** (a) The tomato plant, (b) A leaf of tomato, (c) Tomato fruit. **E.** Floral diagram (can also be pentamerous as given in the floral formula).

Stem: Erect or semi-erect or decumbent covered with short glandular hairs, somewhat angular and winged, with a tendency to become woody at the base, branched. Sympodial branching occurs towards the top so that the successive principal axes are developed from axillary buds and the terminal buds produce inflorescence or abortive branches. Each axillary branch also continues vegetative growth and terminates in an inflorescence. Branching is monopodial towards the base of the plant where inflorescence does not occur.

Leaf: Odd-pinnately compound, usually with 7–9 larger leaflets and a variable number of smaller ones occur between the adjacent pairs of major leaflets; covered with short glandular hairs; phyllotaxy 2/5; leaf structure varies frequently with environmental and edaphic conditions. The leaves are petiolate with long, clasping and decurrent petiole. The main leaflets are shortly stalked, ovate to oblong, acuminate, with margins variously incised or lobed, sometimes entire and tending to roll inwards.

Inflorescence: Usually a 2-ranked raceme or a branched racemose-cyme wth 4–12 or more number of flowers on an inflorescence.

Flower: Yellow, pendent, perfect, bisexual, hypogynous, regular with variable number of floral parts in each floral

whorl. The flowers are pedicellate with a short constricted pedicel; the constriction marks the position of the abscission layer.

Calyx: Sepals (5–10), gamosepalous, consisting of a very short tube terminated by 5–10 lobes; hairy with glandular and non-glandular, unicellular and multicellular hairs.

Corolla: Petals usually (5), gamopetalous, brilliant yellow, rotate with a short tube at the base, lobes reflexed.

Androecium: Usually stamens are 5 in number, sometimes more, partially adnate or undiverged from the corolla tube; filaments short and the connivant anthers are united laterally to form a hollow cone around the pistil, dehiscence longitudinal and introrse.

Gynoecium: Carpels (2), may be more; ovary bilocular (corresponding to number of carpels), superior, often multilocular by the formation of false septa; placentation axile; ovules many in each locule; style elongated and smooth; stigma flattened which extend through and somewhat beyond the encircling androecium.

Floral Formula: $\oplus \; \mathfrak{P} \; K_{(5)} \; \overbrace{C_{(5)} \; A_5} \; \underline{G_{(2)}}$

Pollination: Usually self pollinated due to protogynous, introrse dehiscing and pendent conditions of the flower, crossing does occur in some varieties through entomophily. Some authorities consider that they are seldom self fertilized and crossing occurs with the flowers of the same plant and generally from the same chester. Parthenocarpy is not uncommon in tomato, but the fruits produced are usually small or of poor quality and are seedless.

Fruit: A large berry with various shapes, usually globular or oblate. In cultivated forms, the fruits are multicellular and the cells are irregular in size and outline with a succulent placenta. Quality depends on attractive colour, size and weight.

Seed: Small, oval in outline and much flattened, covered with fine hairs and with abundant endosperm.

Germination: Epigeal.

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Genus: **Nicotiana**

The genus Nicotiana includes nearly 50 species mostly confined to the temperate region and abundantly found in America and Polynasia. It contains erect, viscidly pubescent, herbs, a few are shrubs or arborescents, with petiolate or sessile alternate leaves which are somewhat fleshy, coarse and of ovate or oblong-shape, entire or sinuate and contains the narcotic drug nicotine. The inflorescence is commonly terminal panicle or elongated one sided raceme bearing large, pedicellate, ebracteate, showy, variously coloured, hypogynous, hermaphrodite, regular and with pentamerous symmetrical flowers; the calyx tube is of ovoid tubular shape, 5-fid, greenish-yellow colour with imbricate aestivation and is persistent; the corolla is funnel-shaped, 5-lobed, induplicate in bud; stamens 5, all fertile, attached in the lower part of the corolla tube, filaments filiform; the characteristics of gynoecium is of special importance, ovary bilocular; axile placentation in oblique position; style filiform; stigma capitate, shortly bifid. Fruit is a 2-celled capsule, 2-valved in the middle, valves often again splitting. Seeds very many, small, scarcely compressed, embryo nearly straight.

Nicotiana, although circumscribes a number of species yet the plants that are cultivated for yielding the economic

products of nicotine, tobacco and snuff include, *N. tabacum, N. rustica* and *N. alata*. These are easily identified by the characteristic colours of their flowers. *N. tabacum* bears carmine, pink or very rarely white flowers; in *N. rustica*, they are yellow while in *N. alata* white-tinged with purple below.

Nicotiana rustica Linn.

Hindi: TAMBAKU *English*: Tobacco

Tobacco is a native of South America and the Europeans found it widely grown there by the native tribes. Now it has spread from there to all the continents and is grown in tropical and subtropical areas. As tobacco is only a three months crop it can grow in the far northern and southern latitudes as the summer temperatures prevail for this short period. The temperature requirement of the crop during the growth season varies from 60°F to 100°F and a well distributed rainfall of 20" is sufficient to see the crop through. Heavy rainfall is detrimental to the leaf. The plant is grown for its leaves which contain the alkaloid nicotine having narcotic, medicinal as well as insecticidal properties.

India is now the second largest producer of tobacco and grows nearly 70 crore pounds annually. It is a crop of great in dustrial importance and due to its high popularity in the present age and use in various industries it holds a considerably high place in the world trade. Most of this is consumed as cigarettes, 'biri', 'hookah', pipetobacco or as cheroots. Tobacco is grown in all the states of India but the greatest centres of production are in the Rangpur district of Bengal and Guntur district of Andhra. It is also grown to a considerable extent, in the states of Bihar, U.P. and Punjab. Being a cash crop, this plays an important role in the general agricultural economy of our country.

N. tabacum and *N. rustica* are the extensively cultivated species of tobacco and by far *N. tabacum* cover a larger area. India grows both these species but *N. rustica* is mainly confined to the north and north-eastern parts of the country due to its affinity for cooler climate while *N. tabacum* abounds all over the land. *N. rustica* is a hardy species producing strong tobacco and is greatly esteemed for country cigars, hookah, chewing and snuff. This is characterised by its shorter height, yellow

flowers, round and puckered leaves. *N. tabacum,* on the other hand, usually possesses pink flowers and is tall with long, broad leaves and supplies the major portion of the tobacco of commerce.

Specific varieties of tobaccos have been evolved for specific purposes and probably India ranks high in having an extensive array of cultivated types with specialized methods of growing and curing.

The chief morphological characters, on the basis of which different varieties are isolated are plant habit, shape of the leaves, inflorescence and flower.

BOTANICAL DESCRIPTION

Habit: A cultivated annual herb, sometimes behaves as perennial.

Root: The tobacco plant prior to transplantation possesses a strong tap root which is broken during transplanting and finally the crop bears the adventitious, branched, extensive and fibrous roots, functioning throughout its life.

Stem: Terete, erect, aerial, branched, green, more or less round; glandular viscid-pubescent, herbaceous above but slightly woody at the base; having four minor channels running longitudinally; lower 1 or 2 nodes are prominent, solid; the length and number of the internodes vary in different varieties; in classification of varieties, internodes up to 2 cm. are medium and those over 5 cm. are long; the younger branches have some sticky substance on their surface. Branching usually occurs above and sometimes the lower buds develop into suckers during the later period of growth. Intensive development of suckers during early stages is considered to be an undesirable quality and hence must be checked.

Leaf: Vary a great deal in number, shape, texture and insertion on the stem; simple, sessile or petiolate, petiole more or less flat, winged, glandular, pubescent; shape may be elliptical, lanceolate or ovate; coarse in texture, smooth below, hairy above, surface even or puckered; sometimes fleshy and the younger leaves secreting some sticky substance; margin entire, slightly wavy; apex acute; reticulate unicostate venation; phyllataxy 1/3, more crowded towards the base. The leaves vary in the angles which they make with stem (insertion)—upright,

horizontal or bending at various points in between these two extremes, i.e., at the base, in the centre or at the tip. The

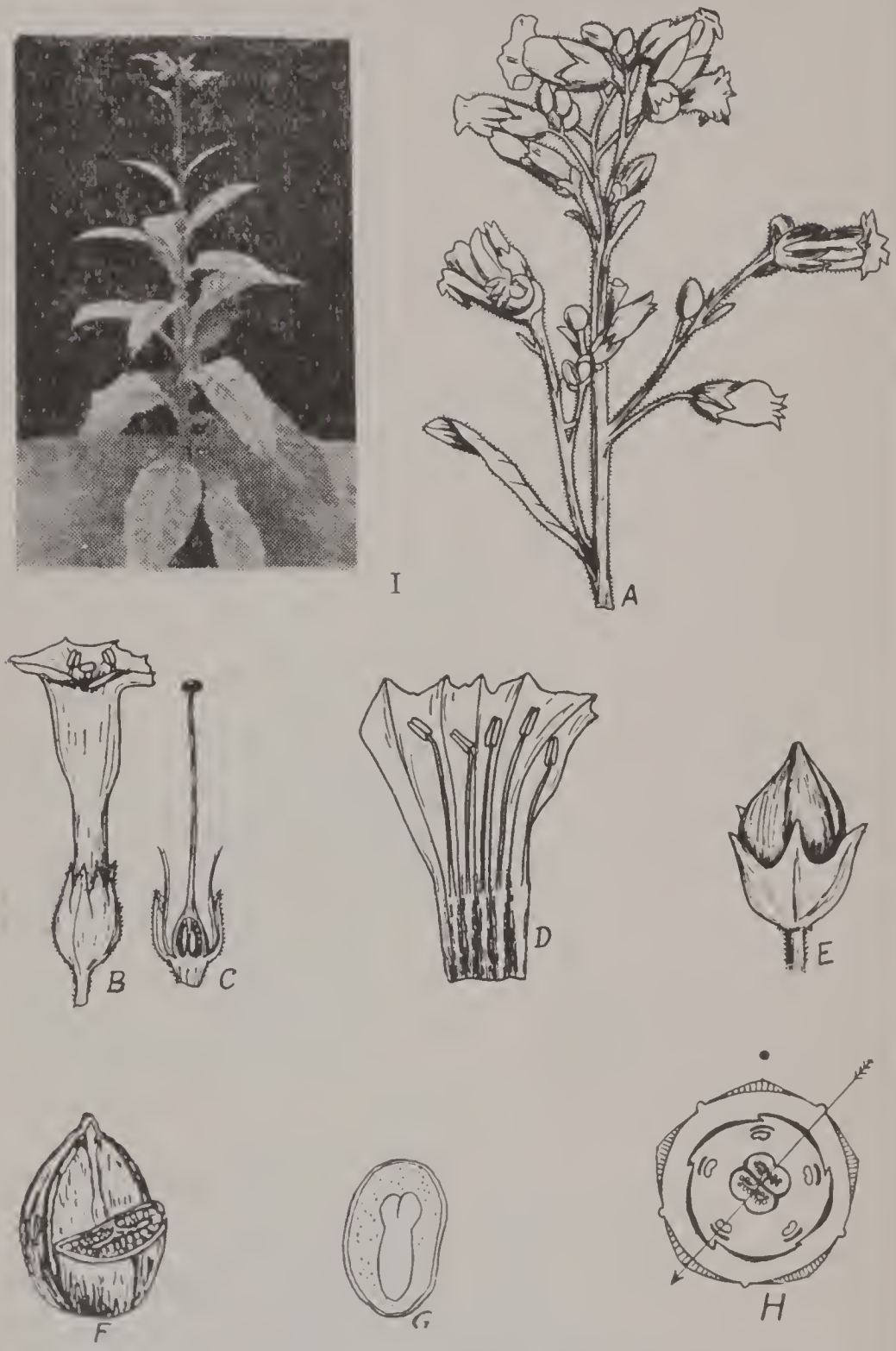

Fig. 53—**TOBACCO Tobacco** (*Nicotiana tabacum*) **plant**

A. Inflorescence (diagramatic). **B.** Flower. **C.** Pistil with vertical section of the ovary. **D.** Epipetalous stamens. **E.** Fruit. **F.** Fruit opening, one half cut transversely. **G.** Longinal section of seed showing straight embryo. **H.** Floral diagram.

leaves tend to vary from base to apex and the upper leaves are smaller, narrower and simpler in structure as compared to lower leaves. Considering all the various characters in which the varieties differ, the leaf shape is considered the chief criterion for the main divisions in the classification with the plant habit next in importance.

It is necessary to induce an even ripening of the leaves of tobacco plants during their later development. This is markedly influenced by *topping* (removal of top portion with inflorescence) and *suckering* (removal of the side branches). The object of these two operations is to minimise the translocation of food material from leaves to other organs and thereby to improve their quality and size.

The foliage is the object of tobacco cultivation which has narcotic poisonous properties. It can not be utilized as such and has to undergo certain processes prior to consumption, the most important being *curing* and *'fermentation'*. These improve the quality of the leaves and also decrease their poisonous effects.

Curing is the most critical step in the preparation of commercial tobacco. The process is an indirect application of artificial heat. The obvious effect is the drying off of the leaf with changes in their physical and chemical compositions. It is said that many enzymes also take part during this process and it is considered by many to be a *"life process"*. After curing, the leaves are subjected to *"sweating"* or *"fermentation"* which improves the *'aroma'* of the tobacco. The changes in fermentation appear to be in continuation with that of curing.

Inflorescence: A terminal close panicle. It may occur near the upper leaves or may be much raised.

Flowers: Yellow or white, pedicellate, hypogynous, hermaphrodite, ebracteate, complete, regular, pentamerous.

Calyx: Sepals (5), gamosepalous, fused below and free above, 5-lobed; lobes unequal, triangular, sub-obtuse, acute apexed, entire margined and having a prominent longitudinal rib; aestivation imbricate in bud; calyx tube campanulate, pubescent, greenish yellow, persistent and completely covering the fruit.

Corolla: Petals (5), gamopetalous; corolla tube cylindric campanulate, inflated about the middle, 5-lobed; lobes smooth

and spreading outward, orbicular; each petal having a prominent midrib; yellowish, glandular pubescent. The relative lengths of the calyx and corolla do not vary much, practically in all the varieties the calyx is 1/3 the length of the corolla.

Androecium: Stamens 5, epipetalous; filaments filiform, fused with the corolla tube at the base, hairy below, unequal, anthers two-lobed, basifixed, all fertile, with longitudinal introrse dehiscence.

Gynoecium: Carpels (2), syncarpous, axile (oblique) placentation; ovary bilocular, superior, thick, fleshy; ovules indefinite, anatropous; style 1, filiform; stigma bilobed, capitate.

Floral formula: $\oplus \; \varnothing \; K_5 \; \overbrace{C_{(5)}} \; A_5 \; \underline{G_{(2)}}$

Pollination: Flowers are self-fertile, protogynous and anthers generally burst as the flowers unfold. It is, therefore, concluded that self-pollination is the rule. Nevertheless, certain amount of cross-pollination is possible by the visitation of insects (2-3%). In some varieties parthenogenesis also occurs.

Fruit: A four-valved, globose capsule with persistent calyx; calyx completely covering the fruit.

Seed: Numerous, egg-shaped, minute, black and reticulated.

Germination: Epigeal.

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Family: **Pedaliaceae**

(Sesamum family)

Pedaliaceae is a small family of 16 genera and about 50 species, mostly maritime or desert plants and found in the tropical and subtropical regions of the globe.

The characteristic features of the family are the possession of 4-loculed or incompletely 4-loculed bicarpellate ovary, the axile placentation, and the usually beaked or barbed fruits.

Familiar Examples:

Sesame or TIL (*Sesamum indicum*), BARA GOKHRU (*Pedalium murex*), BICHHU or BAGHNAKH (*Martynia diandra*).

FLORAL CHARACTERS

Inflorescence: Axillary, dichasia, usually solitary (rarely fascicled or racemose). When solitary, there are two glands

present at the base of the stalk of the flower. These glands are supposed to be metamorphosed flowers.

Flower: Bisexual, zygomorphic, ebracteate, pedicellate, complete, hypogynous (epigynous more rare), pentamerous with decrease in the number of carpels and abortion of one stamen.

Calyx: Sepals 5 (sometimes 4), gamosepalous, basally connate, lobes deep and in valvate aestivation.

Corolla: Petals 5, gamopetalous, broadly tubular, five lobed and somewhat bilabiate, lobes imbricate in bud.

Androecium: Stamens 4, the fifth represented by a small posterior staminode, polyandrous, didynamous (rarely 2), epipetalous; anthers sagittate, 2-celled, dehising longitudinally, introrse.

Gynoecium: Pistil 1; carpels (2), syncarpous; disc hypogynous; ovary superior (rarely inferior), fleshy; bilocular (rarely unilocular) and becoming tetralocular by the formation of a false septum in each locule; placentation axile (very rarely parietal); ovules one to many, anatropous; style 1, filiform, long; stigmas 2.

Floral Formula: $\dagger\ \varnothing\ K_{(5)}\ \widehat{C_{(5)}\ A_{2+2+1\ \text{staminode}}}\ \underline{G_{(2)}}$

Fruit: Hard, indehiscent or usually a 2-valved capsule or nut, indehiscing loculicidally; often spiny or with wings, hooks or thorns.

Seed: Smooth with a thin fleshy endosperm and a small straight embryo.

VEGETATIVE CHARACTERS

Habit: Annual or perennial herbs, rarely shrubs.

Germination: Epigeal.

Root: Tap root system.

Stem: Mostly erect and herbaceous and provided with glandular hairs. The glandular hairs are also present on other parts of the plant.

Leaf: Exstipulate, opposite in lower regions and often spiral or alternate in the upper region, simple, entire or lobed, incised or pedatifid (palmate type with deep lobes forming the claw of a bird).

Economical Importance:

Economically, *Sesamum indicum*, known as Sesame or benne, is an important oil yielding crop, in which the sesame oil is expressed from the seeds which has got a number of uses including an acceptable substitute for olive oil. Some of the species belonging to this family are known as good ornamentals (*Ceratotheca triloba*) while others have some medicinal properties (*Pedalium murex*).

Genus: **Sesamum**

Sesamum is the largest genus under the Pedaliaceae family comprising about 16 species and are commonly found in the tropical and subtropical regions.

The members are erect or prostrate herbs with leaves opposite below alternate above, entire, toothed, lobed or divided. Flowers shortly pedicellate, axillary, solitary or few and fascifiled with small five-partite calyx and bilabiate corolla, tube ventricose; stamens 4, didynamous, included; anthers sagittate; ovary 2-celled but apparently tetralocular; style filiform; stigma 2-lobed. Capsule oblong or ovoid, usually 4-angled (4 chambered), loculicidally 2-valved. Seeds many, obliquely oblong, somewhat compressed.

Sesamum indicum Linn.

Hindi: TIL *English*: Benne Sesame

According to most investigators, sesame originated in southern and south-western Africa and from there it travelled to India. The diverse ecological factors in this country are believed to have given rise to different varieties which spread eastwards to Indo-China, China and Japan and westwards through the mediterranean countries to north Africa and so India is the secondary centre of origin for the different forms now cultivated in different parts of the world, over a wide area both in the tropical and subtropical zones. It is grown in areas with a temperature of 70°F and rainfall of not less than 20″. It grows on plains and at an elevation of 4000 ft. as well. The soils best suited for the crop are light sandy loams, the growth being better as the sandy portion increases. It grows in all parts of the country. Madras, Bombay, Hydera-

bad, Madhya Bharat and U.P. are the most important producers in India. It is grown here in large quantities for the sake of its seeds from which an oil is extracted.

Fig. 54—**BENNE SESAME**

A. A portion of the stem bearing flowers and fruits. **B.** Corolla opened. **C.** Pistil. **D.** Transverse section of ovary. **E.** Fruit dehiscing. **F.** Seed. **G.** Longitudinal section of seed. **H.** Floral diagram.

Til is largely cultivated during the rainy season as a mixed crop for two varieties of seeds, white and black. The black seeded variety yields the best oil which is used for culinary purposes and the manufacture of soap and cosmetics. The white seeds are used for the preparation of sweets.

BOTANICAL DESCRIPTION

Habit: An erect or prostrate annual herb, cultivated for its seeds which yield valuable oil.

Root: Tap root, branched.

Stem: Quadrangular, herbaceous, erect, hairy, glandular.

Leaf: Simple; variable on the same plant, opposite below but alternate above; entire, toothed, lobed or dissected; upper

leaves lanceolate or oblong with uppermost as linear, intermediate leaves ovate and toothed while lower leaves lobed and pedatisect.

Inflorescence: Solitary or axillary in cymes with 2-3 flowers.

Flower: Pedicellate, purple or whitish in colour with purple or yellow marks, suberect or drooping, tubular, complete, bisexual, zygomorphic, hypogynous, pubescent.

Calyx: Sepals (5), gamosepalous, jointed at the base but free at the top; sepals narrow lanceolate, hairy and green.

Corolla: Petals (5), gamopetalous, bilabiate with 5-lobes (2+3), lobes rounded; corolla tube—tubular, pubescent, whitish or purplish with yellow or purple marks.

Androecium: Stamens 4, didynamous, epipetalous; anthers sagittate, versatile, anther cells subparallel and distinct.

Gynoecium: Carpels (2), syncarpous; ovary superior, 2-celled, the cells each soon divided into two chambers by the intrusion of a false dissepiment from between the placentae thus it appears to be 4-celled; style filiform; stigma 2-lobed, smooth; ovules numerous, anatropous.

Floral formula: $\dagger\ \varnothing\ K_5\ \overbrace{C_{2+3}\ A_{2+2}}\ \underline{G_{(2)}}$

Fruit: Capsule, erect, erect, oblong (with 4-grooves), shortly beaked with soft scattered hairs, same width from top to bottom, usually shortly acuminate, 2-valved halfway down or sometimes to the base or ultimately bluntly tetragnous (with 4 grooves); dehiscence from above downwards but rarely to the base.

Seed: Many, compressed with a shallow pit (foveolate), oblong. Generally two varieties are met black and white. The seeds have a high oil content.

Germination: Epigeal.

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CHAPTER XIV

Order: **Campanulales**

The order Campanulales comes under the grade Sympetalae, group Tetracyclicae and subgroup Inferae. According to Rendle, this consists of four families Campanulaceae, Goodeniaceae, Stylidiaecae and Compositae with nearly 16000 species.

The order generally includes herbaceous, more rarely woody plants, often containing latex-vessels or oil-passages. The inflorescence is racemose with a tendency to aggregation in heads. The flowers are characterised by the floral parts usually in 4-whorls; bisexual (or unisexual by suppression); regular or zygomorphic; perianth and androecium typically pentamerous (calyx in some cases modified to pappus) but the number of carpels generally fewer (except in some Campanulaceae), the stamen in a single whorl and the bithecal anthers often coherent to connate forming a tube into which the pollen is ejected, the style developes into a brush by which the pollen is swept out at the top of the tube. This pollen presentation mechanism is a distinguishing feaure of the order and is simple at the same time remarkably effective. The ovary is characteristically inferior (rarely more or less superior), often unilocular with a single ovule or several–celled with ∞ – ovules in each cell.

Family: **Compositae**

Compositae is the largest family of flowering plants, comprising of about 900 genera with over 14,000 species (more than 10% of the total). It is a cosmopolitan family with remarkable diversity in habit. They are well marked and cannot be confused with any other family. The enormous majority of species belonging to this family are herbaceous mesophytes, although xerophytes are not uncommon and hydrophytes, epiphytes and climbers are rare. There are about 696 species of Compositae as yet identified in India.

The family is generally recognised by the inflorescence—an involucrate head or capitulum with ray and disc florets; involucre of several whorls of bracts; the 5-lobed gamopetalous

corollas; the usual presence of a pappus, the 5 syngenesious, epipetalous stamens and the inferior bicarpellate uniloculate ovary with a single basal ovule. The fruit is a cypsela with exalbuminous seeds.

Familiar Examples:

Sunflower or SURAJ-MUKHI (*Helianthus annuus);* safflower or KUSUM (*Carthamus tinctorius*); lettuce or SALAD (*Lactuca sativa*); globe artichoke or HATHICHAK (*Cynara cardunculus);* endive and chickory (*Cichorium*); Dandelion (*Taraxacum officinale*); Dahlia; *Zinnia; Cosmos; Chrysanthemum; Calendula;* marigold (*Tagetes*) etc.

FLORAL CHARACTERS

Inflorescence: The inflorescence is the characteristic of the family. Flowers are small and in most cases condensed into a *head* or *capitulum* of the racemose type in which the axis gets flattened with slight convexity (known as *'receptacle'*) and the oldest flowers are towards the periphery and the youngest towards the centre or short spike in rare cases. The marginal flowers are called *'ray-florets'* and the central flowers *'disc-florets'*. Although mostly flattened, the common receptacle can also be variously shaped—concavely, convexly or sometimes conical to columnar. The surface of the receptacle may be smooth or hairy and scaly bracts or bristles may be present for individual flowers, which are deciduous or persistent or may be ebracteate. The capitulum is ordinarily surrounded by an involucre of one to many series of distinct or variously connate bracts (*phyllaries*) which are usually green, uniseriate or multiseriate and perform the same function as that of sepals of ordinary flowers. These capitula are again arranged in many cases into larger inflorescences—racemes, corymbs etc.

Flower (floret): Pentamerous; regular or medianly zygomorphic; bisexual, unisexual (♀) or neuter as: (a) both ray florets and disc florets may be bisexual, (b) ray florets female while disc florets bisexual, (c) ray florets neuter and disc florets bisexual. The flowers are usually represented by one of the three types: (a) with tubular corolla, actinomorphic, 5-lobed with conspicuous tube and usually a short limb. This may occupy the entire head or all except the periphery and

are usually bisexual (sometimes unisexual and the plants then monoecious or dioecious), (b) with ligulate corolla, zygomorphic, usually lorate with 3–5 apical teeth (teeth sometimes absent) and a very short tube. This may be restricted to the periphery of the radiate head (when they are neutral or pistillate) or may cover the entire receptacle (when they are usually bisexual, sometimes unisexual and the plants dioecious), and (c) with bilabiate corolla, zygomorphic, modified from a tubular corolla and having a 3-lobed upper lip and 2 slender usually recurved lower lips.

Calyx: Apparently missing or modified into a cluster of hairs, bristles or scales—called *"pappus"*, in the form of an epigynous ring which persist in the fruit and assist in the dispersal of seeds.

Corolla: Petals (5), gamopetalous and usually represented as tubular, ligulate or bilabiate as described above.

Androecium: Stamens 5; isomerous; inserted in the corolla (epipetalous); filaments generally free but anthers united (syngenesious), forming a cylinder around the style often variously appendaged at apex or base of anther sac; connective generally prolonged above the anthers; anthers two-celled, dehiscing introrsely by longitudinal slits; the filaments distinct and coiled before anthesis—expanding and straightening as the anthers are forced upward by the elongating stigmas and style. Stamens are absent in female flowers.

Gynoecium: Pistil 1, carpels (2), syncarpous, ovary inferior, unilocular, formed from the two median carpels, containing a single anatropous ascending ovule with one integument; style 1, slender, filiform, in the fertile flowers divided at the top into two limbs which are stigmatic on the inner face and, at least in the bisexual flowers bear hairs on the outer faces or at the tip; in the female flowers generally undivided.

Floral Formulae:

General : $K_p \, \widehat{C_{(5)} \, A_{5)}} \, \overline{G_{(2)}}$

(Disc floret) Bisexuale : $\oplus \, ☿ \, K_p \, \widehat{C_{(5)} \, A_{(5)}} \, \overline{G_{(2)}}$

(Ray floret) Female : $† \, ♀ \, K_p \, C_{(5)} \, A_{(0)} \, \overline{G_{(2)}}$

(Ray floret) Neuter : $† \quad K_p \, C_{(5)} \, A_{(0)} \, G_{(0)}$

Pollination: Pollination in Compositae is interesting. The flowers have both the devices of being cross pollinated or self pollinated. The protandrous condition ensures cross-pollination which is usually attained by entomophily. The flowers are although small but being coloured and massed together closely in heads do not lose its conspicuousness. The arrangement of ray florets and the presence of the involucre of bracts give the inflorescence (capitulum) the appearance of a single flower, showy and attractive to insects. The advantage of this arrangement is gained by the fact that a single insect visitor may fertilize many flowers in a short time. This is much simple as well as effective. The insects are also attracted by the honey secreting gland situated round the base of the style and protected from rain and short lipped insects by the tube of the corolla. Pollen mechanism, pollen protection, nectar placement etc., are so perfectly worked out that cross pollination by highly specialized insects becomes an unusual feature of the group.

In bisexual flowers, there is also a mechanism for self-fertilization. During anthesis, the style with its stigmas tightly closed against one another, is comparatively short, reaching up to or projecting a small distance into the anther tube. Pollens are shed early due to the protandrous condition of the flower and collect within the anther tube. As the style grows it presses the pollen little by little out at the upper end of the tube where it comes in contact with the visiting insects. In the end the style emerges out of the tube and the stigmas separate from each other. In great many cases the stigmas subsequently curl back to such an extent as to touch the pollen upon their own style. Stigmas being now receptive, self-fertilization is attained if cross-fertilization fails. Thus every flower (floret) of the bisexual type is almost certain to get the seeds. The mechanism is quite the simplest and most perfect that exists for attaining the desired ends.

Fruit: A one-seeded inferior achene (cypsela), often crowned by the persistent or deciduous pappus or the pappus lacking; sometimes enveloped by a persistent bract.

Seed: Erect, filling the fruit; the coat uniting with the pericarp; endosperm absent; embryo large and straight with a short inferior radicle and flat or semicylindrical, sometimes involute cotyledons.

VEGETATIVE CHARACTERS

Habit: Herbs or shrubs, rarely trees or climbers, majority of these are mesophytes, a few are aquatics.

Germination: Usually epigeal.

Root: Usually a tap-root but may become tuberous or thickened for storage of food (e.g. Dahlia, artichoke). The reserve carbohydrate *inulin* is often present in these tubers as solution in the cell sap.

Stem: Erect or prostrate, usually herbaceous, rarely woody, more or less branched but often undeveloped and giving rise to rosette forms. Oil-ducts are almost universally found in the cortex which are sometimes replaced by lacti-ferous vessels.

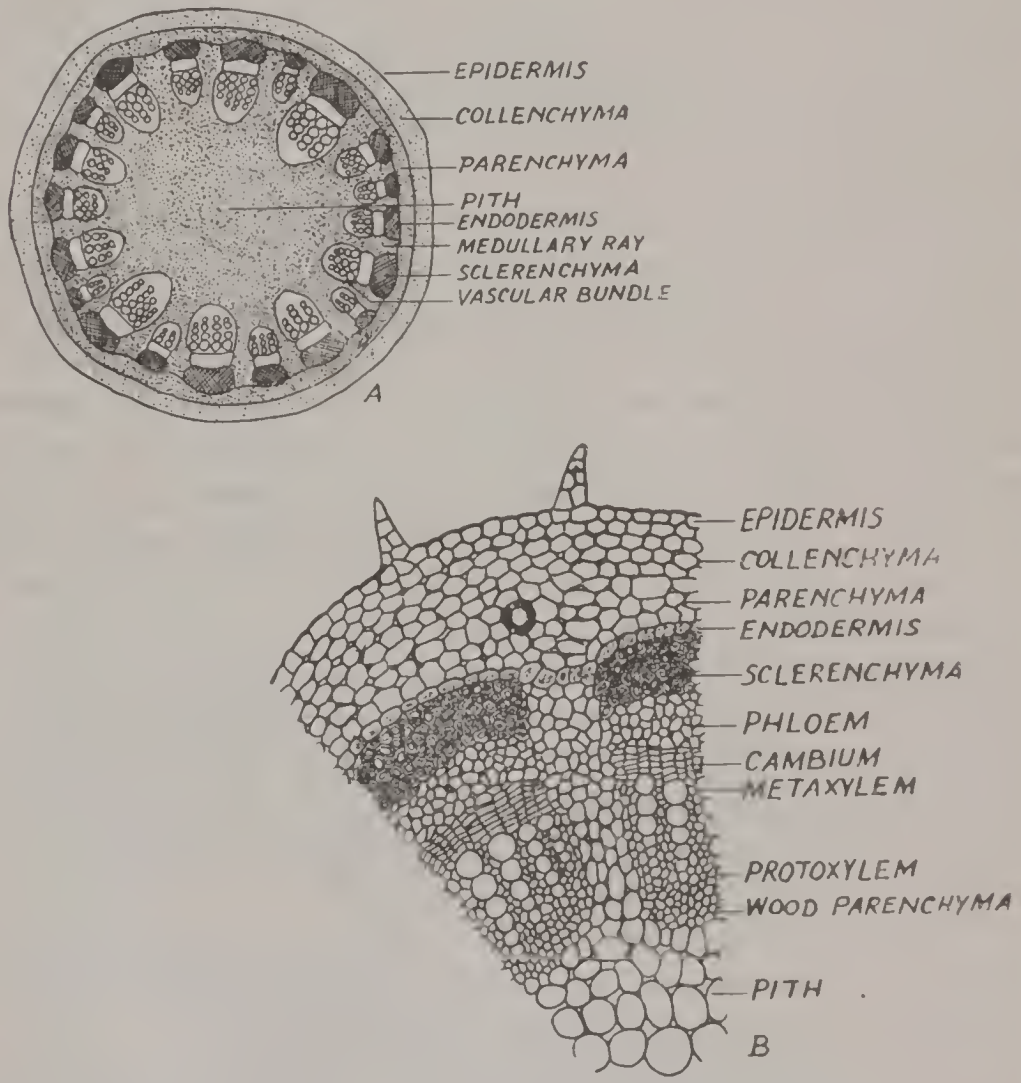

Fig. 55.—Anatomy of sunflower stem.

A. Transverse section of a young sunflower stem under low power. **B.** Transverse section of a portion of young sunflower stem under high power.

Leaf: Generally alternate, frequently radical, more rarely opposite or whorled in few cases; simple or pinnately or palmately lobed, divided or compoun frequently in basal rosettes, sometimes heath-like, needle-like, or reduced to scales in some xerophytes, frequently decurrent or sometimes auriculate; exstipulate; hairy (varying in form and density) or glabrous, surface smooth or rough, oil ducts and latex present in some.

Phylogenic consideration of Compositae:

The Compositae is generally regarded as occupying the highest position in the plant kingdom. Apart from the presence of two distinct accessory whorls of perianth (calyx-modified and corolla), gamopetalous condition, epigynous ovary, definite number of stamens etc., indicating the highly evolved state of the Compositae, there are several useful concurrent peculiarities observed owing to which this family has been found to be much successful in nature and thus more preponderant and cosmopolitan in distribution:

1. The massing of the flowers in heads, surrounded by involucral bracts causes greater conspicuousness (especially when ray florets are present); considerable saving of the corolla material etc. There are two advantages in this characteristic inflorescence—firstly, a single insect can fertilize several flowers in a short time without having to fly from one to the other; secondly, the involucral bracts, or ray florets, or both, often close up over the central flowers in cold or wet weather, thus protecting the flowers.

2. The very simple and effective floral mechanism, which ensures protection of honey and pollen; exclusion of the very short-lipped insects, but not too great specialization for a very narrow circle of visitors; prevention of self—and chance of cross-fertilization till the last possible moment; certainty of self fertilization if the cross fails.

3. Highly evolved mechanism for the fruit dispersal—pappus helps wind dispersal; presence of sticky pappus, stout barbed bristles, hooked involucral bracts or sticky bracts help the adherence of fruits to animals and thus the fruits are distributed to a long distance.

Economic Importance:

Economically the family Compositae is of considerable importance including members which are important sources of food to man (lettuce, artichokes, endive and chickory), oil yielders (sunflower, safflower), natural dyes (safflower), and a large number of useful garden ornamentals (Chrysanthemum, Cosmos, Zinnia, Dahlia, strawflowers, marigolds, sunflower, perennial asters etc.). A few supply contact insecticides (*Chrysanthemum coccineum*) or medicinal and patented preparations. Some are notably poisonous to live stocks (*Xanthium, Solidago*) or cause hay fever (*Ambrosia artemissiifolia* and *Solidago*) while a few are noxious weeds in garden and field.

Genus: Carthamus

The genus Carthamus belongs to the family Compositae under the tribe Cynareae (Thistle group), commonly found in the Mediterranean region, in Asia and Africa. There are about 25 species as yet identified to be belonging to this genus and many of the members are widely cultivated.

These members of the genus are thistle like herbs. Leaves alternate, rigid spinescent (with spines), Heads (inflorescence) usually homogamous (stamen and stigma ripen together); flowers yellow, white or purplish; all bisexual, fertile (rarely a few ray-florets are female or neuter); similar and not ligulate, tubular, tube slender, limb (free portion of the united corolla) oblong, dilated at the base, 5-cleft (or 0 in female flowers). Involucre ovoid or subglobose, increasing in length inwards, often thorny; bracts many seriated, inner dry entire or with a short fringed appendage, outer with a thorny appendage (sometimes absent in cultivated species). Receptacle flat, densely bristly. Anthers generally tailed, bases sagittate, upper connate (*syngenesious*), filaments usually hairy in the middle. Style arms short or long, thickened beneath the arms and bearing collecting hairs. Fruits achenes, glabrous, obovoid, four angled or compressed, with or without the persistent many seriated pappus.

Of the species belonging to Carthamus, only safflower (*C. tinctorious*) is of considerable economic value as an important oil and dye yielding crop.

Carthamus tinctorius Linn.

Hindi: KUSUM *English*: Safflower

The safflower dye was a popular and important colouring stuff both in India and outside before the advent of aniline

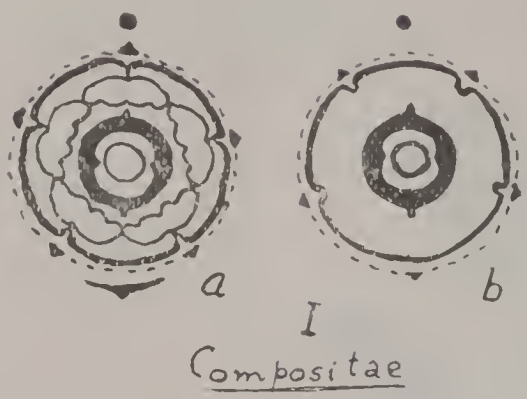

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Fig. 56—**SAFFLOWER**

A. A flowering branch of safflower. **B.** Inflorescence of safflower. **C.** A flower. **D.** Arrangement of a typical flower head of a Compositae (sunflower). **E.** Disc floret showing lobed and tubular corolla, projecting tip of pistil surrounded by stamens, **F.** Ray floret. **G, H.** Ray flower and fruit of Dandelion. **I.** (a) Floral diagram of Compositae (disc floret). (b) Floral diagram of ray floret. **J.** The chrysanthemum plant—an example of Compositae.

dyes which has now pushed it to insignificance. The safflower can be grown both as a rainfed and irrigated crop but it dislikes heavy rainfall. The average rainfall suited to the crop is between 25″ to 40″. Black cotton soil of South India and loams and light alluvial soils in other parts are put under extensive cultivation of this crop. The seeds of safflower are an important source of edible oil. The origin of the plant is a disputable question, opinions differ as to whether it be India, Africa and Arabia.

BOTANICAL DESCRIPTION

Habit: A cultivated herbaceous annual grown in winter in Northern India.

Root: Tap-root.

Stem: Glabrous, thistle like herb and much branched near the top.

Leaf: Sessile, alternate, rigid, spinescent, oblong and lanceolate. The degree of sharpness of the apex differs in different varieties, so also the serration of the margin and the number and size of the spines.

Inflorescence: A large compact head or capitulum borne on the terminal ends of the branches well beyond the large leaves. Each main branch ends in a capitulum, the flowers of which begin to open before those of the inflorescences on the secondary branches.

Involucre Bracts: Many seriated; outer involucre bracts foliaceous, ovate-oblong, constricted above the base, green, spinulose or entire; inner involucre bracts ovate-oblong, acute and narrower. The character of the involucre is believed to be different in the oil yielding and dye yielding forms. The spinose bracts are believed to be associated with the oil yielding forms, whereas the dye yielding forms are mostly entire.

Flower: Consisting of 'disc' and 'ray' florets, all similarly tubular, tube slender, limb oblong; bisexual (a few marginal ones or ray florets may be sterile or female and when present it is ligulate), homogamous, epigynous. The colour varies from light yellow (oil yielding) to orange or red (die yielding) these colours show the presence of carthamine.

Calyx: Generally absent or -may be visible in certain cases in pappus form.

Corolla: Petals (5), gamopetalous, tubular, tube 5-lobed.

Androecium: Stamens 5, syngenesious, filaments hairy in the middle, anthers sagittate at the base, dehiscence longitudinal and introrse.

Gynoecium: Pistil 1; carpels (2), syncarpous; ovary inferior, unilocular, with one basal anatropous ovule; style 1, filiform with bifid stigma.

Floral formulae:

Bisexual (tubular): $\oplus\ \mathfrak{Z}\ K_p\ \overbrace{C_{(5)}}\ A_{(5)}\ \underline{G_{(2)}}$

Female (ligulate) | Neuter (,,) } $\dagger\ ♀$ or $0\ K_p\ C_{(5)}\ A_0\ G_{(2)}$ or 0

Pollination: Both self-and cross-pollination are likely to take place in this crop by the visitation of insects but autogamy is more common.

Fruit: Achene, white, often deformed, obliquely four angled with four projecting ribs, truncate at the top; pappus absent.

Seed: Filling the fruit, exalbuminous. The size of the seed varies, depending on the influence of environment and the position of the seed on the capitulum. Oil content 20–30%.

Germination: Epigeal.

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APPENDIX

The practicals of crop systematics consist mainly of describing a plant in botanical language and assorting it to its proper family on the basis of some of its distinguishing characters (to be found along with each family described in the text). The student should examine closely the material suplied for study, in order to make out all the details of structure that can be seen by the naked eye, or in some minute structures, "tease out" under the dissecting microscope with fine needles. The observed structures are drawn on the drawing sheets of the laboratory journal and properly labelled. This should always be borne in mind that *"nothing has been truly observed unless it has been drawn"*. Usually the following sketches need be drawn: (1) A twig with the flower and inflorescence. (2) Longitudinal section of a flower from a suitable angle showing the arrangement of different floral whorls. (3) Detail structure of different floral parts with their peculiarities, if any. (4) Transverse section of the ovary showing placentation. (5) Floral diagram. The description of species given in the text will be found to be much useful for these classes.

A few practical turns of crop botany are devoted to the studies in plant anatomy. This consists of cutting of thinnest possible sections, which are stained or treated with some chemicals for differentiation of tissues and ultimately mounted on a slide and observed under microscope. Here also, drawing of the structure and general arrangement of tissues, as observed under the low power and high power of the microscope, becomes essential. The following two figures will enable the students to bring out the details:

(1) ***Ground plan:*** The general arrangement of the tissues in a full section is represented schematically by this method and the tissues are distinguished merely by means of different hatchings. Cells are not to be represented here. This is more suitable for low power views. (Fig. 22A)

(2) ***Sector drawing:*** Here a sector of the above is shown in detail where the cell construction and their arrangements are represented as accurately as possible. (Fig. 22B) This is drawn from high-power examination. Student should not be schematic in this case as has been done in making the ground plan. When making the drawing of cells, first lay down the outline by the hard pencil. (H) showing the shape of the

cells. Now build the thickness of the various cell walls on these separately. Use the soft pencil (HB) for the lignified tissues. Concentrate on the sector that is being studied closely. Do not try to make drawings too extensive. Select a few important cells at a significant point of the tissues and concentrate on representing them exactly as you see them. Do not leave the cells looking like an isolated group, but indicate in your drawing, by leaving a few unfinished cells at the edges, that they are part of a continuous tissue.

METHOD OF FREE-HAND SECTION CUTTING AND SHARPENING OF RAZOR

Always use a reliable flat ground razor for free-hand section cutting, this will be safe and will cut uniform sections.

One very suitable way of holding the razor is to turn back the handle at right angles to the back of the blade and grasp it so that the handle passes between the second and third fingers, with the thumb pressed against the milled surface of the thick shank of the blade, the first and second fingers against the back of the blade and the third and fourth fingers against the prolongation of the blade, beyond the point of its attachment to the sheath (Fig. 22A). In this way the razor is firmly held, while at the same time allowing for free movement.

For section cutting, brace the forearms against the sides, hold the object firmly in the left hand between the thumb and the first finger (Fig. 22B). Rest the blade of the razor on the upper side of the first finger for controlling the stroke. The first finger should be kept as straight as possible, while the thumb is kept well down below the surface of the material out of the way of the razor edge. Cut with a long, oblique stroke from left to right. The edge of the razor and the direction of the stroke should be toward the body and not away from it as in the cutting of a pencil. *One material and the razor should always be kept wet with water.* By slightly and progressively increasing the pressure with the razor on the first finger, a number of sections can be cut without moving the material or the thumb.

Take care while cutting, so that the material is not cut obliquely. It is best to start cutting with the edge of the razor *'on top of'* rather *'against the side of'* the material. This gives good thin sections. If you are unable to get a complete section,

trim the section in a way that it includes at least a portion of the tissues from the centre to the circumference and then mount it on the slide. For hard objects, the razor will need frequent sharpenings. Those sections which seem to be worth further treatment should be placed at once in water in a watch glass. Use a fine brush for removing sections from the razor edge.

Sharpening and stropping of razor:

A good razor is one of the most valuable tools of a botanist and it should be handled with the greatest care. Defective or careless sharpening and stropping may damage the set of the blade and the razor is made worse than it was before.

While sharpening the razor put some water or oil on the hone surface and press the razor edge on the hone keeping the left thumb pressed on the blade-end and move the razor slowly against the hone surface. Remember that the face of the razor edge should be away from the body while "moving off" and it should face towards the body while "moving in".

The razor should be dried and stropped immediatly after sharpening on hone or after use, to preserve the keen edge of the blade. Stropping should be done first on the leather side of the strop, on which a little oil, soap or stropping paste is rubbed in, and then, on the canvas side. While stropping, take care that the turn is made over the back of the blade and not over the edge. Turning over the edge not only cuts the strop but turns back the edge of the blade. Razors are improved by frequent stropping.

USE OF THE COMPOUND MICROSCOPE

A compound microscope is an optical instrument consisting of a combination of lenses and used for magnifying an object which is too minute to be adequately seen by the unaided eye. Skill in its use is very important in botany. This being very costly and delicate precision instrument, any careless handling throws the mechanism out of adjustment and brings a great loss to the laboratory. Hence be very cautious in using this instrument.

General rules for using the microscope:

Remember always that there is only one way to use a microscope and get it firmly fixed in your mind by practice and never depart from it.

(1) Carry the microscope in an upright manner and place it very gently on the table or in the cabinet.

(2) Clean the lenses and mirror very, very gently with lens paper or a chamois leather or a soft muslin cloth which should be used for no other purpose. Never use a scratchy duster and keep your fingers off the lens at all times.

(3) Never use alcohol on any part of the microscope. The cement between the lenses and frequently the finish on the microscope is alcohol-soluble. If the oil-immersion lens is used, remove the immersion oil promptly after use. Gently wipe off the bulk of the oil with lens paper followed by use of another sheet slightly moistened with xylol. If the lens paper is not available soft muslin cloth can be used.

(4) Never use your microscope under direct sunlight, this will spoil your eyes. Natural daylight from north is the best. For artificial light opal or pearl electric bulb should be used.

(5) Never use a slide without a cover slip and keep the top of the cover slip clean and dry. Never allow the objective to touch the slide.

(6) Always focus in an upward direction whenever using the coarse adjustment. Only the fine adjustment should be used when focussing downward.

(7) Before changing the low-power objective to a high-power objective by rotating the nose piece, very carefully make it sure that the high-power objective does not make contact with the slide—detect it before any damage occurs. If the instrument is parfocal (i.e., the objectives can be interchanged and are each approximately in focus without raising or lowering the tube), there is no difficulty, otherwise, such high-power objectives must be focussed separately.

(8) Practise using both eyes alternately and practise keeping open the eye not in use. This saves a great deal of strain and however difficult it may seem at first it will rapidly become an unconscious habit.

(9) It is always wise to follow the stepwise operation procedure while using the microscope.

(10) Completely cover the instrument when not in use. Large size bell-jar or a large piece of clean cheesecloth or old soft muslin can serve the purpose.

Operation of the microscope:

1. *Magnification power*: Determine the degree of magnification of the microscope. The degree of magnification is marked on each lens. The total magnification may be found by multiplying the magnification of the objective by that of the eye piece.

2. *Setting up the instrument*: Focus and control the amount of light that illuminates the object which is placed on the stage above the opening by the help of the mirror, condenser and diaphragm. Use the plane mirror surface if the instrument has a substage condenser but the concave surface if it does not have a condenser. The microscope is workable only when the lens is completely and uniformly lighted. For the proper adjustment of light follow the following steps: (i) First observe from the side that light passes through the stage hole and then place a slide in position and focus on the object with the low power objective. Adjust the mirror and the condenser to get the best illumination. (ii) Focus the condenser (if it is there) so that the grain of the ground glass is visible in the plane of the object. Now throw this slightly out of focus so that the grain does not interfere with the image. (iii) Diaphragm will be used to control the light when the object is on the stage. Remove the ocular and while looking down the tube adjust the substage iris diaphragm to a diameter which will completely illuminate the back lens of the objective. To open it wider will introduce unnecessary glare into the optical system. For fresh mounts usually less light is needed and for prepared slides one has to work normally with full illumination.

3. *Focussing*: First be sure that the object is directly over the centre of the opening in the stage. Then watching from the side (not through the eye piece) bring down the tube slowly by means of coarse adjustment until the low-power objective is about $\frac{1}{4}$ inch above the slide. Now, looking through the eye piece, focus up with the coarse adjustment until the object comes into view. Bring it into sharp focus with the fine adjustment.

To observe the material under high-power objective, carefully turn the revolving nose-piece until the high-power objective clicks into place under the tube. A slight turn of the fine adjustment will now bring the object into focus, if it is not already in focus. In case, you fail to focus under high-power

objective by the above procedure ('parfocal' adjustment), proceed as follows. Watching from the side bring down the tube with high-power objective by the coarse adjustment until the objective almost touches the slide. Now look through the eyepiece and focus up slowly with the fine adjustment until the object comes into focus. Repeat this change from low to high-power until you are thoroughly familiar with the microscope.

4. *Oil immersion*: To use the oil-immersion objective, the simplest and safest procedure is the following: Raise the tube and rotate the low-power objective into position. Lower the condenser. Place a drop of immersion oil (cidar wood oil) on the top lens of the condenser and refocus the condenser. This can be avoided for ordinary purposes. Accurately center the object in the field under high power. Raise the tube approximately $\frac{1}{2}$ inch. Place a drop of immersion oil on the slide over the point of light visible. Turn the oil immersion objective into position by revolving the nose-piece until the objective clicks into position. Now hold your head to one side of the microscope in order to observe the level of the objective and slowly lower the tube with the coarse adjustment until the objective lens just contacts the drop of oil. Now while looking into the ocular, slowly and most carefully focus downward *with the fine adjustment* until the image comes into focus. Adjust the diaphragm if necessary.

MINIMUM REQUISITES OF THE PRACTICAL CLASS

(a) For students

A full set of dissecting instruments is not needed, rather, purchase the following separately from a reliable laboratory furnisher.

(1) Razor, flat-sided for section cutting. Hollow ground razors are not good for this purpose, nor are safety razor blades.

(2) Dissecting needles—2.

(3) A pair of fine-tipped forceps, preferably with curved tips.

(4) Scalpel—1.

(5) Safety razor blade—1.

(6) Medium size camel-hair brush—2.

(7) Chamois leather—1 piece.

(8) A large piece of clean cheese cloth or old soft muslin for polishing slides.

(9) Laboratory journal containing one side ruled and hard surfaced drawing paper of good quality (the exact number of sheets needed for each will be instructed by the teacher).

(10) Pencils—2: 1 soft (HB) and 1 hard (H).

(11) A small size slide box for preserving permanent microscope preparations, which will be submitted in the final examination.

(12) One pocket lens, magnifying at least 10X.

(b) For laboratory

For each student:

(1) Watch glasses (25 c.c. capacity)—2 or 5 (for temporary or permanent preparations)..

(2) Beaker 250 c.c.—1.

(3) Staining set containing 11 dropping bottles with the following reagents (the set can be placed between two students. Canada balsam is kept in a special container:

*Ethyl alcohol series:**

(i) Absolute Ethyl alcohol, (ii) 90% alcohol, (iii) 70% alcohol, (iv) 50% alcohol, (v) 30% alcohol.

(vi) Phloroglucin (5% aqueous or alcoholic solution).

(vii) Safranin (1 gm. in 100 c.c. of 50% alcohol or in water).

(viii) Light green (1 gm. in 100 c.c. of 90% alcohol).

The commercial absolute alcohol of our country is usually of about 95% concentration or sometimes even less. Water may be removed to get 100% concentration (absolute) by distilling or by putting a *"drier"* into the alcohol. The following procedure can be followed:

Heat copper sulphate crystals ($CuSo_4$, $4H_2O$) in an iron vessel over an open flame until the blue crystals break up into a gray powder. Disappearance of blue colour shows that the copper sulphate crystals are now free of its water of crystallization. Cool the crystals and pour immediately into the absolute alcohol bottle. Tightly stopper the bottle and leave for 24 hours. After 24 hours pour off and add fresh copper sulphate, shake and repeat the operation until the fresh copper sulphate no longer gets conspicuous blue when put into the alcohol. When the alcohol can be mixed with xylol without becoming milky, it may be called absolute alcohol. If care is used when the absolute alcohol is poured from the bottle, clear alcohol free from particles of the calcined copper sulphate can be secured.

Dilute the alcohol to the desired concentrations (90%, 70%, 50% and 30%) by subtracting the numeral expressing the desired percentage from 100 and mixing that number of cubic centimeters (c.c.) of distilled water with the number of cubic centimeters of absolute alcohol corresponding to the concentration sought, e.g., for 90%, dilute 10 c.c. distilled water with 90 c.c. absolute alcohol.

(ix) Xylol (xylene).

(x) Iodine solution (1% in potassium iodide solution).

(xi) Glycerine.

(xii) Neutral Canada balsam: Canada balsam obtained from scientific stores are usually too thin due to excess of xylol. If the container is left unstoppered for a time it will reach a thicker consistency and be in better condition for use. It is then kept in a special container with a short piece of glass rod and never in a dropping bottle. If the Canada balsam becomes very thick after long use, add a little xylol to make it more thin.

(4) Dissecting microscope—1.

(5) Compound microscope (student's microscope)—1.

(6) Microscopic slides (3″×1″)—2.

(7) Microscopic cover slips ($\frac{3}{4}$ circles, No. 2 thickness)—clean and free from grease and dust.

For general use:

(8) Razor strop—1 for 25 students.

(9) Hone—1 for 25 students.

(10) Binocular microscope (to be handled by the instructor).

(11) Camera lucida (to be handled by the instructor).

INTRODUCTION TO MICROCHEMICAL TEST REAGENT AND STAINS TO BE USED IN THE CLASS

Phloroglucin: A chemical applied simultaneously with hydrochloric acid gives lignified walls a reddish violet colour (microchemical test).

Safranin: This is one of the most useful of the aniline stains and safranin O is commonly used in the botanical laboratories. It is the most generally useful of all the red stains and is quite permanent. Lignified, suberized, cutinized and chitinized structures stain red, as do also the chromosomes, nucleoli, and centrosomes.

Light green: It is an acid stain, soluble in water, alcohol or clove oil. It stains quickly and forms a sharp contrast with safranin. The green rapidly reduces the safranin and consequently the staining must not be too prolonged. It stains the cellulose walls green.

PREPARATION OF MATERIAL

Materials to be handled for section cutting need some preliminary treatment for successful results. This includes killing, fixing, hardening and preserving of the material. The purpose of a killing agent is to bring the life processes to a sudden termination, while a fixing agent is used to fix the cells and their contents in as nearly the living condition as possible. The proverbial saying goes *'kill your material before it is dead'*. This implies that if the killing is neglected, the plant becomes useless for later study. Hardening by dehydration with alcohol is required by soft material to make the cutting of sections easy. Preserving liquids are used to store the tissues for a long period without rendering the material useless for further study.

Formalin-acetic acid–alcohol (F.A.A.) mixture:

This combination, for general anatomical work, might also be called a universal fixing agent. About 5 c.c. of glacial acetic acid and 5 c.c. of commercial formalin to 90 c.c. of 50% or 70% alcohol is generally satisfactory.

Ninety-five per cent alcohol:

This is in quite general use for material which is needed only for rough work. It is very convenient, since it kills, fixes and preserves at the same time and needs no changing or washing. The only difficulty with this fixing agent is that the material becomes hard and brittle if left for a long time. A mixture 95% alcohol and glycerine (1:1) is found to be much helpful in keeping stems, roots and similar objects for an indefinite period.

TEMPORARY MOUNTS AND MICROCHEMICAL TESTS

A. ***Safranin method:***

(1) Transfer a few good sections by means of a brush in a watch glass containing 10–15 drops of an alcoholic solution of safranin (1% solution in 50% alcohol). Allow the sections to lie there until deep red.

(2) Then transfer the sections to another watch glass containing tap water and rinse off the excess stain by gently moving the sections about in the water. If necessary use acid (HCl) water.

(3) Place a drop of glycerine on a slide and transfer the section on it.

(4) Place a cover-glass over the material. In placing the cover-glass, do not drop in flat upon the drop of glycerine, but place one side of it down first, and allow it to squeeze the glycerine along under it. Blot out the excess of glycerine flowing out of the cover slip. Observe under the microscope.

Safranin stains the xylem a bright red, but, with judicious washing, is entirely removed from the cambium and cellulose elements of the phloem.

B. ***phloroglucin method*** (microchemical test):

This method is helpful in the differentiation of lignified from unlignified tissues. It gives the lignified walls a reddish violet colour. The preparations do not keep.

(1) Transfer a few good sections in a watch glass containing a few drops of phloroglucin and wait for 2–3 minutes.

(2) Mount the section on phloroglucin–hydrochloric acid mixture.

PERMANENT MOUNTING WITH DOUBLE STAINING

Temporary preparations do not keep for long whereas permanent preparations after being properly stained and dehydrated can be kept for a long period. During the course, the student will prepare a set of permanent mounts. These are to be properly made, labelled and turned in whenever called for. It is important that the directions for staining and mounting be kept readily accessible at all times in the laboratory.

The temporary preparations as described earlier consist either using of single stain (safranin) or testing of the lignified tissues (phloroglucin). These methods bring out only some particular structures, but in most cases, for ordinary laboratory purposes, double staining method is used for permanent preparations. This affords a sharp contrast. The double-staining method with safranin–light green will now be described here that distinguished clearly the red-stained and green-stained tissues. One should bear in mind that the success of such procedures entirely rests on our patient and constant observation and gaining of experience with different types of tissues.

Plant tissues contain a high percentage of water. The final stage in the permanent mounting of sections is imbedding

the section in Canada balsam—a colourless, transparent material, the purified resin or pitch of the balsam fir (*Abies balsamea*), which will not mix with water. It is necessary therefore to remove all the water from the sections by means of alcohol, then replace the alcohol with xylol (or xylene), and finally mount the section in Canada balsam. Stainings (double) are generally done at some stages before the treatment with xylol. Xylol is a clearing agent which is miscible with both alcohol and Canada balsam. After the material has been dehydrated, it should be brought gradually into xylol which renders the object transparent.

Procedure for double staining with safranin and light green:

(1) Transfer the free hand sections from the razor's blade to a watch glass containing water.

(2) & (3) Stepwise dehydrate the best few sections in 30% and 50% alcohol respectively, each for 3–5 minutes, in different watch glasses.

(4) Stain the sections with Safranin O (1% in 50% alcohol) for 5 to 10 minutes under a covered watch glass until the sections are deep red in colour.

(5) Wash out the excess stain by retransfering to 50% alcohol and keep for 3 to 5 minutes. If necessary rinse with acidulated 50% alcohol for a few seconds by gently moving the sections about in the water, but stop while the safranin is still somewhat stronger than desired in the finished mount. Be careful not to remove too much of the safranin, the second stain 'Light green' (Step 8) rapidly reduces the safranin colour.

(6) & (7) Proceed stepwise dehydration in 70% and 90% alcohol respectively, each for 3 to 5 minutes in different watch glasses.

(8) Dip the sections individually in light green and immediately transfer to absolute alcohol. The light green not only stains vigorously but reduces the safranin colour and hence should not be prolonged more than a few seconds.

(9), (10) & (11) Now clear the sections first in clove oil, then in absolute alcohol and xylol mixture 1:1 and finally in xylol, in different watch glasses, giving 3 to 5 minutes time in each. It is advisable to use a separate brush for these steps.

(12) Mount the section in Canada balsam. Should air bubbles be detected in the balsam shortly after mounting, heat

a dissection needle in a flame and touch each with its tip, when they will be found to disappear. If too much Canada balsam has been used, some of it usually spreads beyond the edge of the cover glass, or on its surface. To remove this, wait until the balsam hardens, scratch off with a knife and clean the surface of the glass with a bit of cotton moistened with xylol.

(13) Label the slide, indicating kind of section and subject.

The safranin will impart a red colour to the suberized, cutinized and lignified cells, while the light green will stain cellulose walls green.

MACERATION

This is one of the oldest and easiest method of recognising the internal plant tissues. This gives a correct impression of the structure of the tissues in a three dimensional view and is found to be very helpful for the beginners.

The method consists of treating the stem or other organ with chemicals which dissolve the middle lamellae and allow the cells to become separated from one another. Boil the herbaceous stem slices (Cucurbita stem is a good material) for 10 to 15 minutes or more till cooked. After cooking cells should begin separating easily. If necessary use nitric acid or sodium hydroxide for better dissociation. Wash thoroughly and stain with safranin or phloroglucin.

The first few turns of the anatomy practical should entirely be devoted for the 'study of tissues' with the transverse, longitudinal and macerated views of the same tissue. Cucurbita stem, maize stem, sunflower stem are good materials for preliminary studies.

Abortive. Barren or imperfectly developed.

Accaulescent. It is a descriptive term meaning stemless or apparently stemless i.e., with very short, scarcely evident stem.

Accrescent. Continuing to grow.

Accumbent. Applies to cotyledons which have their edges lying against the radicle as in many Cruciferae.

Achene. A small, dry, indehiscent, hard one-chambered one-seeded simple fruit where pericarp of the fruit is free from the seed coat e.g. Clematis; also applied to the fruit of Compositae with tight thin pericarp.

Achlamydeous. A flower without any perianth.

Acicular. Long needle-shaped.

Acropetal. Arising from base towards apex in a longitudinal plane.

Actinomorphic. Flowers with radial symmetry; regular; such as may be bisected in two or more planes into similar halves.

Acuminate. Applicable to an acute apex narrow tapering to a sharp point.

Acute. Apex tapering to a sharp point but more broadly than acuminate.

Acyclic. Spirally arranged.

Adaxial. Facing the primary axis.

Adelphous. Combined in groups.

Adherent. A term to designate the union of members of dissimilar organs—touching each other conveniently but are not fused.

Adnate. United, a congenital fusion of unlike parts e.g. epipetalous; See also connate, adherent.

Adventitious. (root or buds). Appearing on occasion, rather than resident in the usual places and order as roots springing from cuttings of the stem or from leaves.

Aestivation. The mode in which the parts of the perianth are folded and arranged in the bud.

Aggregate Fruit. A fruit formed by the coherence of the pistils that were distinct in the flower, as in the raspberry and blackberry.

Albuminous. Provided with albumen or endosperm or perisperm, or both.

Allogamy. Cross-pollination.

Alternate. Arranged on opposite sides of the stem but at different levels in a zig zag manner (as applied to leaves).

Amphitropous (ovule). When the ovule is placed transversely, at right angles to its stalk or funicle and the ovule is twisted round. The micropyle and the chalaza are in the same straight line.

Anastomosing. Leaves with cross veins forming a net work.

Anatropous. Bent over or inverted; said of an ovule when it bends along the funicle so that the micropyle lies close to the hilum at one end and opposite the chalaza.

Androecium. The stamens of a flower taken collectively.

Androgynous. Inflorescence bearing both male and female flowers.

Anemophilous. Pollinated by wind, literally, "wind loving".

Angiosperms. Flowering plants, or plants which bear their seeds in an enclosed structure, the ovary.

Annual. A plant which completes its life cycle within one year.

Anterior. On the front side; away from the axis; that part of a flower which faces outwards from the axis of inflorescence.

Anther. The enlarged upper portion of the stamen which bears the pollen.

Anthesis. The act of flowering; the period of opening of a flower; the period of pollination.

Antipetalous. Inserted opposite the petals.

Apetalous. Without petals.

Apiculate. A leaf terminated by a short, sharp, flexible point.

Apocarpous. Carpels free or separate; compare with syncarpous.

Aposepalous or *polysepalous*. Sepals free.

Arborescent. Tree-like in habit.

Aristate. Bearing an awn or bristle e.g. glumes of some grasses.

Articulate. Provided with nodes or joints.

Ascending. Rising up; becoming erect from a prostate or sub-prostrate state.

Asexual. Without sex.

Attenuate. Showing a long gradual taper, applied to bases or apices of parts, drawn out into a long, slender point.

Auricle. An ear-like appendage occurring at base of the leaf blade in many grasses and in other flowering plants.

Autogamy. Self-pollination.

Awn. A stiff bristle-like, very fine, terminal appendage; a beard.

Axil. Upper angle that a petiole or peduncle makes with the stem to which it is attached.

Axile Placentation. The placentae bearing the ovules develop from the central axis e.g. lemon, china rose, potato.

Axillary. Situated at the axil.

Axis. The line running lengthwise through the centre of an organ, as of a flower or a stem; also applied to the stem itself, and the torus or receptacle of a flower.

Basifixed. Attached or fixed by the base to its support (ovule or anther).

Basipetal. Developing from the apex towards the base in a longitudinal plane (opposite of acropetal).

Bearded. With bristle-like hair, awn or with zone of pubescence.

Berry. A pulpy, indehiscent fruit with few or many seeds e.g. tomato.

Bi-, Bis-. Two e.g. Bi-carpellary (with two carpels). Bi-farious (in opposite vertical rows); Bi-fid (two cleft), Bi-labiate (two-lipped), Bi-lobus (two-lobed); Bi-pinnate (when compound leaf is twice pinnate i.e., midrib produces secondary axes which bear the leaflets); Bi-seriate (in two whorls, as perianth comprised of a calyx and corolla) etc.

Biennial. A plant that completes its life cycle in two growing seasons.

Bisexual. A perfect flower, having both stamens and carpets.

Bract. A modified leaf which subtends a flower or flower cluster. *Bracteole*—A secondary bract.

Bristly. Bearing bristles (stiff strong hairs).

Bud. An undeveloped shoot or shoot in the resting condition. *Terminal bud*—a bud at the apex of a stem. *Lateral bud*—a bud elsewhere on a stem than at the apex. *Axillary bud*—a lateral bud produced in the axil of a leaf. *Adventitious bud*—a bud arising anywhere except at the stem apex, or in the leaf-axils. Adventitious buds may arise from stems, from roots in some plants, and rarely from leaves.

Bulb. A modified underground shoot consisting of a very much shortened stem (disc), with fleshy, scale-like leaves borne on it.

Caducous. Falling off very early.

Calyx. The whorl of sepals.

Calyx tube. The tube of a gamosepalous calyx; also used for the hypanthium or receptacle of perigynous or epigynous flowers. *Cambium*—Meristematic tissue which, by its division, continues the growth in thickness of the stem or root.

Campanulate. Bell-shaped.

Campylotropous. When the amphitropous ovule is bent round like a horse-shoe, so that the micropyle and the chalaza do not line in the same straight line and come close together e.g. in Cruciferae.

Capitate. Formed like a pin-head; collected into a dense cluster; the inflorescence of Compositae.

Capitulum. A dense inflorescence made of an aggregation of usually sessile flowers e.g. in Compositae.

Capsule. A simple, dry, dehiscent fruit with several or many seeds formed from a compound ovary and having openings at or between the junctions of the carpels, e.g. in Cruciferae.

Carpel. A simple pistil or one of the members of a compound pistil, probably evolved from a leaf. A megasporophyll bearing female spores.

Carpophore. A wiry stalk that supports each half (carpel) of the dehiscing fruit of Umbelliferae.

Caruncle. A wart-like appendage at the base of a seed.

Caryopsis or *Grain.* A simple, one-seeded, dry indehiscent fruit derived from single, simple pistil, (similar to achene) where the seed coat is permanently fused to the pericarp over its entire surface e.g. in Graminaceae.

Catkin. A peculiar form of inflorescence consisting of an elongated axis (spicate) covered with bracts in the axils of which are one-rarely two-sexual flowers usually without, rarely seldom with very inconspicuous perianth. The whole inflorescence is deciduous together.

Caudate. Bearing a tail-like appendage.

Caulescent. With evident stem above ground.

Cauline. Pertaining to the stem.

Chaff. A small, thin, more or less dry and membranaceous scale or bract (e.g. the bracts in the heads of Compositae).

Chartaceous. Of papery texture.

Chotomous. Divided several times into forks (di-, tri- etc.).

Ciliate. Bordered with hairs along the margin.

Cincinnus. A helicoid cyme.

Circumscissile. Dehiscing transversly by a line around the fruit or anther, the valve usually coming off as an unhinged lid of a box.

Clavate. Club-shaped; gradually thickened upward.

Claw. The long narrow petiole-like base of the petals or sepals, as in mustard.

Cleistogamy. Small, closed, mostly underground self pollinated flowers.

Coccus (Pl. Cocci). The seed-like dehiscent or indehiscent segment of the dry fruit which separate out at maturity.

Coherent and *Cohesion.* To designate the union of members of the same whorl touching one another more or less adhesively but not fused.

Columella. A term applied to the persistent axis of a fruit from which the rest of the fruit falls away in some cases when ripe.

Commissure. The plane of division between two carpels in Umbelliferous fruits.

Complicate. Folded together lengthwise upon itself.

Compound leaf. A leaf made up of a number of divisions or leaflets. Ternately compound—when the leaflets are in three's. Palmately compound—when the leaflets are all attached at a common point of the tip of the petiole. Pinnately compound—when arranged along a common rachis.

Compound pistil. Pistil developed by the connation of more than one carpel.

Conduplicate. Folded lengthwise along midrib.

Confluent. Merging together.

Connate. Congenital union as one body or organ of similar structure, said of leaves in which the bases of two opposite leaves appear to have fused about the stem.

Connective. The filament connecting the two anther-lobes by a sort of midrib, specially when the cells are separated.

Connivent. Coming together; converging or bending toward one another of two or more similar organs (anthers).

Contiguous. Touching without fusion irrespective of like or unlike parts.

Contorted. Twisted or convolute in aestivation e.g., Cotton.

Convergent. Said of venation when the prominent veins arising from the base of the lamina meet or converge near the apex.

Convolute. Twisted aestivation with margins overlapping.

Cordate. Heart-shaped; when the leaf is broad at the base with a deep notch and narrow at the apex, e.g., Betel Vine.

Coriaceous. Of leathery texture.

Corm. A short, erect, thick, solid, bulb-like part of the stem, usually underground with stored food.

Corniculate. Terminating in a small hornlike protuberance.

Corolla. The petals taken collectively.

Corona. A collar-like appendage.

Corymb. The flat topped racemose inflorescence, the rachis is comparatively short and bears unequally stalked flowers. In this type of inflorescence the lower pedicels elongate more than the higher ones and are arranged in such fashion that all the flowers are brought more or less to the same level, e.g., Candytuft (Iberis).

Costate. Furnished with one (uni–) or more (multi–) primary ribs or veins in a leaf.

Cotyledons. Leaves arising from the basal node of the embryo in a seed plant, often adapted for food storage, food absorption or other special function.

Crenate. Shallowly round-toothed margin of a leaf.

Crested. With irregularly elevated toothed ridge.

Crispate. Curled.

Crown. Corona, the additional whorl of floral part formed at the throat of the corolla–made up of lobes, scales or hairs, free or united e.g., Dodder. This term is also used for a part of rhizome with a large bud suitable for use in propogation; the top or stem part of a fleshy tap root.

Cruciform. In the form of a cross.

Crustaceous. Hard and brittle.

Cryptogams. Seedless plants, which do not bear evident flowers.

Culm. Jointed stem with solid nodes and hollow internodes e.g. Bamboo.

Cuneate. Wedge-shaped leaf, as in Water Cabbage–triangular with the narrow end at the point of attachment.

Cupule. Cup-like structure at base of some fruits e.g., palms.

Cuspidate. When the apex of the leaf ends in an elongated, sharp-pointed, hard and rigid point e.g., Date.

Cuticle. The outer layer of the outer wall of the epidermis, consisting largely of cutin.

Cyathium. A type of inflorescence characteristic of Euphorbia –the unisexual flowers condensed and congested within a bracteate envelope from which they come out at anthesis, the long stalked, bracteate, female flower in the centre surrounded by many stalked male flowers. The flowers open centrifugally.

Cyclic. Arranged in whorls not spirally.

Cymba. Woody, durable, boat-like spathe which encloses the inflorescence (e.g. in Palms).

Cyme. A determinate inflorescence, in which the central or apical flower opens first.

Cypsela. A dry inferior achene from bicarpellary ovary. In

such case the pericarp is separable from the seed, e.g., in Compositae.

Deciduous. Falling off, not persistent.

Decumbent. Growing flat along the ground with the ascending tip.

Decurrent. Produced down, as a sessil leaf when the blade is prolonged below the insertion along the stem forming a winged appendage.

Decussate. The arrangement of each pair of opposite phyllotaxy at right angle to the next pair.

Dehiscent. Opening at maturity (said of capsule or anther).

Dentate. Provided with teeth pointing outward, not forward.

Determinate. Definite, ending with a bud.

Diadelphous. Said of stamens when united into two sets.

Diandrous. Flowers with two stamens.

Dichasium. A cymose method of branching in which each axis ends in a flower or other short unbranched axis from beneath which arise a pair of opposite lateral branches.

Dichlamydeous. With two whorls of petals.

Dichogamous. Flowers in which stamens and pistils mature at different times.

Dichotomous. A method of branching which leads to the bifurcation of each axis at the tip.

Diclinous. Unisexual, having stamens and pistils in separate flowers.

Didymous. Occurring in pairs.

Didynamous. Stamens in two unequal pairs e.g., in mustard.

Diffuse. Loosely spreading.

Digitate. Divided as fingers radiating from the palm.

Dimerous. With the parts in pairs.

Dimidiate. Rudimentary or appearing to be so.

Dimorphous. Having two different forms.

Dioecious. Where sexes occur on different plants.

Diplostemonous. Stamens in two whorls those of the outer whorl opposite the sepals and the inner whorl alternate with them and opposite to the petals.

Disc. A flattening of the receptacle above the calyx and under or outside the pistil e.g., in Anacardiaceae. Also used in referring to the common receptacle of the head of Compositae.

Disk-flower. Which have a tubular and five-toothed or five lobed corolla and occupy the centre of the head of Compositae.

Dissected. Deeply divided.

Dissemination. The scattering of seed, pollen, spores, etc.

Distichous. Arranged alternately in two opposite rows, said of leaves, the two rows lying in the same vertical plane.

Distinct. Like parts not united.

Dorsal. Situated at the back, remote from the axis.

Dorsifixed. Fixed by the back of; jointed to filament by its whole length; often, but not necessarily, versatile e.g., in Lilium.

Dorsiventral. Leaf with definite dorsal and ventral surfaces-flattened.

Drupe or *Stone fruit.* It is a fleshy fruit from a single carpel almost always one-seeded-the inner part of the ovary wall transformed into a stony tissue and surrounding the seed as in the peach.

Ebracteate. Without bracts.

Echinate. With long spreading spines.

Elliptical. Broadest at the middle and tapering broadly towards each end.

Emarginate. Notched at the apex.

Embryo. The rudimentary plant contained in the seed.

Endocarp. The inner layer of the pericarp, or fruit wall.

Endosperm. The tissue with stored food (albumen) found in some seeds outside the embryo.

Ensiform. Sword-shaped.

Entire. Margin without serrations.

Entomophilous. Insect-pollinated.

Epicalyx. A whorl of bracts just beneath the calyx.

Epicarp. The outermost layer of the fruit.

Epigeal. When in germination the cotyledons are raised above the ground free from the seed and become leaf-like.

Epigynous. Apparently above the ovary, as when the calyx is adnate to it.

Epipetalous. Stamens adhering to the corolla. When they are attached to the perianth—*Epiphyllous.*

Epiphyte. Plants grow upon other plants without drawing their nutrients.

Equitant. In vertical rows when leaves are placed astride one another.

Exalbuminous. Without albumen (non-endospermic).

Excurrent. Where main stem continues to grow beyond margin and the tree takes a pyramidal shape.

Exocarp. The outer layer of the pericarp, or fruit.

Exserted. Projection outwards as anthers beyond the petals.

Extrorse. Facing outward from the center of the flower.

Falcate. Sickle-shaped.

False septum or dissepiment. Usually a late developed inner wall of an ovary which is not formed due to incurved edges of the carpels.

Fascicle. A close cluster of branches. *Fasciculate*—in dense clusters.

Female flower. Which bears an ovary containing ovules and capable of fertilization. A flower which only bears an imperfect ovary is not considered a female flower.

Fertile. Capable of giving fruit. A fertile flower is synonymous with a perfect female flower.

Fertilization. The union of male and female elments resulting in a zygote.

Fibrous roots. Roots in tufts of uniform length, as in grasses.

Filament. The stalk of a stamen supporting the anther.

Filiform. Thread–like.

Fimbriate. Fringed along the edge.

Fistular. Hollow stem of herbaceous plants.

Flexuous. Having a wavy from (stem).

Floccose. Wooly with locks of dense soft silky hairs that are easily detached.

Floret. Small individual flower of a cluster (e.g., in Compositae, Graminae).

Flower. A reproductive short shoot, consisting of an axis (receptacle) bearing essential organs or sporophylls, the androecium only (staminate), gynoecium only (pistillate) or both in one (perfect, bisexual, hermaphrodite).

Follicle. A dry dehiscent fruit of a single carpel dehiscing along the ventral suture.

Free. Not united with other members; distinct.

Fruit. The ovary and its contents after the fertilization of the ovules together with any external integral portion of it.

Fruticose. Shrubby.

Fugacious. Falling off early.

Funicle. The stalk by which the ovule is joined to the placenta of the ovary.

Fusiform. Spindle–shaped.

Gamo-. United; *Gamopetalous*–petals united; *Gamophyllous*–perianth united; *Gamosepalous–sepals united.*

Geniculate. Abruptly bent.

Glabrous. Not hairy.

Gland. An organ secreting fluid e.g., nectary, oil etc.

Glandular. Having glands or relating to glands.

Glaucous. Covered with a bloom, or whitish substance that rubs off.

Glume. The bracts and bracteoles on the spikelets of the grasses and sedges, referring especially to the two empty bracts at the base.

Gynandrous. Stamens which are adnate to the pistil.

Gynobasic. Applied to a style arising from the base of the carpel or ovary.

Gynoecium or *Gynaecium.* The carpel, ovary or assemblage of carpels in a flower together with their appendages.

Hastate. With two pointed lobes shaped like an arrowhead projecting at perpendicular at the base.

Haustoria. The suckers of parasites.

Head or *Capitulum.* A form of inflorescence consisting of a more or less dense cluster of sessile flowers which open centripetally.

Herbaceous. Soft, not woody.

Hermaphrodite. A perfect flower with both male and female organs; bisexual.

Hesperidium. The fruit of the orange or other citrus plants.

Heterogamous. Said of flower heads with two or more kinds or forms of florets.

Hilum. The scar on seed coat indicating the point of attachment between the stalk and the seed.

Hirsute. With stiff, moderately long and spreading hairs.

Hispid. Furnished with rough bristly hairs.

Homo-. Alike, similar.

Homogamous. Said of flower heads with similar florets.

Hyaline. Transparent.

Hypanthium. An enlargement of the torus of the flowers under the calyx or perianth.

Hypocotyl. The axis of an embryo below the cotyledons. This develops into radicle after seed germination.

Hypogeal. Germination in which the cotyledons remain in the seed.

Hypogynous. A flower is hypogynous when the gynaecium is situated at the top of the thalamus and the androecium, corolla and calyx are successively placed below it. In such a flower the gynaecium is said to be superior and the other sets are inferior, e.g., Brinjal, Poppy.

Imbricate. Overlapping (aestivation).

Imparipinnate. Pinnate with a terminal odd leaflet.

Imperfect (flower). Unisexual flower.

Incised. Notched at the margin.

Included. Not projecting or protruded.

Incomplete (flower). Flower lacking one or more of four sets of floral parts—calyx, corolla, androecium and gynoecium.

Incumbent. Leaning upon, applied to cotyledons when the back of one rests against the radicle; anthers are incumbent when turned inward.

Indefinite. Inconstant in number; applied also to racemose inflorescence with continuous growth in length.

Indehiscent. Not opening in a regular manner at maturity (seed pod or anther).

Indeterminate. Of indefinite growth as a racemose inflorescence.

Induplicate. Rolled inwards on both sides.

Inferior. Below, said of ovary when it is beneath the calyx (epigynous condition).

Inflorescence. Flower cluster; more correctly mode of flower bearing.

Infundibular. Funnel-shaped.

Integuments. The coats of the ovule.

Inter—. Between.

Internode. Space between two nodes of a stem.

Interpetiolar. Said of stipules of opposite leaves when they are inserted between the petioles i.e., across the stem.

Intrapetiolar. Applied to stipules of single leaves when they are connate by their margins so as to form apparently one stipule.

Introrse. Said of anther facing inward or facing the stigma.

Involucre. A whorl of bracts or leaves subtending a flower or inflorescence as in compositae; *Involucel*—a secondary involucre; a small involucre as the bracts subtending the secondary umbels.

Involute. Margins of leaf rolled inwards toward the mid rib.

Irregular (flower). Unsymmetrical, one in which any whorl has members not all alike and incapable of being divided into two equal halves.

Isomerous. Having an equal number of members.

Jointed. With distinct nodes and internodes.

Keel. The anterior petals in the Papilionaceae.

Keeled. Ridged like the keel of a boat.

Kernal. The contents of the putamen of a drupe.

Labiate. With projecting lip; *Bilabiate*—two lipped.

Lacerate. Deeply and irregularly divided at the margin.

Lactiferous. Containnig latex (milky sap).

Lamina. Leaf blade or expanded portion.

Lanceolate. Much longer (about three times) than broad, widening above the base and gradually tapering to the apex; lance-shaped.

Latex. Milky sap contained in special vessels or cells of the tissues.

Leaflet. One of the blades of a compound leaf.

Legume. A simple fruit of single carpel dehiscing on both sutures e.g., Leguminosae.

Lemma. Glume like bract of grass spikelet bearing in its axil a floret which with palea it encloses.

Lenticular. Lens–shaped.

Lianous. Woody climber.

Ligulate. Strap-shaped or like a tongue e.g., ray floret of Compositae.

Ligule. The annular collar-like process at the junction of the leaf blade and sheath in grasses.

Limb. The expanded part of gamopetalous corolla, in contradistinction to the tube or claw.

Linear. Long and narrow with sides nearly parallel, as in grasses.

Lip. A projecting part of an unequally divided corolla or calyx.

Locule. A cavity in the ovary, usually containing ovules.

Loculicidal. Dehiscing down midrib of each cell or loculus.

Lodicule. Two small scale-like structures usually much swollen at the time of flowering to represent the inner whorl of a rudimentary perianth.

Lomentum. A leguminous fruit constricted between the seeds, breaking into one-seeded parts.

Membranous or *membranaceous.* Thin, dry, not green and flexible.

Mericarp. One of the halves of a fruit of Umbelliferae.

Mesocarp. The middle layer of the pericarp.

Micropyle. Canal through the integuments of an ovule at the top most end of the nucellus.

Monadelphous (stamens). Concrescent in one bundle by their filaments.

Monocarpous. Having one carpel.

Monochasium. A kind of cymose inflorescence where a cyme reduced to single flowers on each axis (the laterals of the dichasium having been lost by reduction).

Monochlamydous. With one whorl of perianth segments.

Monoecious. With male and female flowers on the same plant.

Mucronate. Tipped with a very short, hard abrupt point.

Multiple fruit. Fruit formed from several flowers into a single structure having a common axis (e.g., mulberry).

Muricate. Rough with sharp straight points.

Mutation. Sudden change in the internal hereditary constitution.

Muticious. Without appendages.

Naked flower. Without perianth.

Napiform. Turnip-shaped.

Nectary. A nectar secreting gland.

Neutral flower. A sterile flower.

Nut. A hard, dry, indehiscent, one seeded fruit.

Ob. Inverted.

Obcordate. Inverted heart-shaped.

Obdiplostemonous. Said of stamens in two whorls, the outer whorl of stamens opposite to the sepals.

Oblanceolate. Inversely lanceolate, i.e., long, narrow and tapering toward the base, but broadest at the distal third than at the middle.

Oblique. One-half larger than the other, unequal-sided nerves, those making acute angle with the midrib.

Oblong. Much longer than broad with the sides nearly parallel.

Obovate. Reverse of ovate, i.e., egg-shaped with the broad end towards the apex.

Obsolete. Aborted.

Obtuse. Tapering abruptly to a point.

Ontogeny. The developmental cycle of an individual; the opposite of phylogeny.

Operculate. Provided with an operculum like a capsule which splits transversely.

Operculum. A lid.

Orbicular or *Orbiculate.* Flat with the outline circular.

Orthotropous. When an ovule is straight with the micropyle opposite to the chalaza.

Oval. broadly elyptical.

Ovary. The hollow chamber formed by the infolded sporophylls in which the ovules are borne on thickened placentae or cushions. *Superior-ovary*—When borne above the point of attachment of perianth and stamens, or surrounded by an hypanthium that is not adnate to it; *Inferior ovary*—when below attachment of the floral envelopes and adnate to them; *half-inferior*—when intermediate.

Ovate. With the outline like that of an egg, the broader end below the middle.

Ovoid. A solid with oval outline.

Ovule. The egg containing unit of the ovary which after fertilization becomes the seed.

Palea or *Pale.* The chaffy scale, specifically on the upper of the two bracts which subtend a flower.

Palmate. Divided and arranged like the leaves of a fan.

Palmatifid. Cut about halfway down in a palmate form.

Panicle. A compound raceme with pedicellate flowers e.g., in Oat.

Papillose. Bearing minute nipple shaped projections.

Pappus. The modified outer perianth of Compositae borne on the ovary, being hairy, bristle-like, scales or otherwise.

Parietal. Borne on the sides or wall of a locule as ovules in the ovary (placentation).

Paripinnate. In a pinnate compound leaf when the leaflets are even in number it is said to be paripinnate e.g., Tamarind.

Pedate. Palmately divided with the lateral segments 2— cleft.

Pedicel. The ultimate stock supporting a single flower in an inflorescence. *Pedicellate*—having a pedicel.

Peduncle. The stalk supporting a solitary flower or fruit, or a cluster of flowers or fruits.

Pellucid. Transparent or translucent.

Peltate. Shield-shaped.

Pendulous. Drooping.

Penicillate. Bordered or tipped with brush like hairs.

Pentamerous. Having the members in each whorl of the flower in fives.

Pepo. A sort of berry with a hard rind, as the gourd.

Perianth. Sepals and petals together constitute the perianth; this term is especially used when the calyx and corolla are similar in form and texture or are represented by a single whorl; flowers without perianth are known as naked flowers.

Pericarp. The wall of the ovary referring specially to fruit.

Perigynous. Inserted around but away from the ovary and not beneath it, as when calyx, corolla and stamens arise from the edge of a cup-shaped hypanthium.

Persistant. Remaining attached.

Petal. One of the divisions of corolla, usually coloured and showy.

Petiole. The stalk of a leaf.

Phanerogam. Plants bearing seeds.

Phyllary. A bract of the involucre.

Phyllotaxy. The arrangement of leaves or floral parts on their axis; generally expressed numerically by a fraction, the numerator representing the number of revolutions of a spiral made in passing from one leaf past each successive leaf to reach the leaf directly above the intial leaf, and the denominator representing the number of leaves passed in the spiral thus made. Alternate—when single leaf arises at each node e.g., Tobacco; Opposite—When two leaves arise at each node, e.g., Guava; whorled—when there are more than two leaves at each node, e.g., Oleander.

Phylogeny. The racial or genetical relationship or development of organisms.

Pilose. Thinly sprinkled with long soft simple hairs.

Pinna. (pl. pinnae) primary division of pinnate leaf.

Pinnule. The secondary division of tripinnate leaf.

Pinnate. A compound leaf is so called when the leaflets are arranged on either side of common axis; said of venation when the principal veins extend from the midrib toward the margin and are more or less parallel.

Pinnatisect. Pinnately cut nearly to the common axis.

Pinnatisect or *Pinnatifid.* Pinnately cut nearly to the common axis.

Pistil. The female organ of a flower consisting normally of ovary, style and stigma.

Pistillode. A rudimentary or barren pistil.

Placenta. That portion of the interior of an ovary on which the ovules are attached.

Placentation. The orientation of the placentae. Parietal—attached to the wall; *axile*—ovules borne at or near the centre on the axis formed by the union and fusion of the septa and usually in vertical rows; *free-central*—ovules borne at or near the centre on the axis formed by the union and fusion of the septa and usually in vertical rows; *free-central* —ovules borne on a central column with no septa present; *basal*—borne at the base of the ovary.

Plumose. With fine hairs.

Pod. The same as legume, but has a wider application, being used to denote any dry dehiscent many seeded fruit, especially when it is much longer than broad.

Pollen. Minute powder—like grains contained in the anther cells, containing the male element.

Pollination. The transfer of pollen grains from the anther to the stigma.

Polyandry. Androecium with indefinite number of stamens.

Polyadelphous. Having the stamens united by the filaments into many sets or bundles.

Polygamous. With hermaphrodite and unisexual flowers on the same plants.

Polypetalous. With distinct petals.

Polyphyllous—Said of a perianth having distinct leaves or segments.

Polysepalous. With distinct sepals.

Pome. A succulent fruit with seeds in many cartilaginous dry cells e.g., Apple, Pear.

Poricidal. Dehiscing by pores whose valves are often flaplike.

Posterior. Said of that part of flower which is nearest to the axis of inflorescence; superior.

Prickly. Armed with prickles—a sharply, pointed stiff outgrowth of the epidermis.

Procumbent or *Prostrate.* Lying flat or close to the ground.

Protandrous. Anthers maturing earlier than stigma of the same flower.

Protogynous. Stigma becomes receptive earlier than the anthers are matured of the same flower.

Pubescent. Covered with short soft straight simple hairs.

Pulvinus. The swollen base of petioles.

Pyriform. Pear–shaped; obovoid with a tapering base.

Raceme. The inflorescence of the indefinite kind in which the flowers are borne on pedicels of more or less the same length along a single undivided axis or rachis, the oldest flowers being lower most. Racemose—Having flowers in raceme like inflorescences.

Receptacle. Torus; the part of the floral axis (pedicel or peduncle) on which some or all of the flower parts are borne; the common axis of the flowers of a capitulum; the hypanthium of a perigynous or epigynous flower.

Rachilla or *Rhachilla.* The secondary rachis of a compound spike; the rachis of spikelet of grasses.

Rachis. The principal axis of a pinnate leaf of an inflorescence.

Radical. Relating to or springing from the root.

Radicle. The axis of an embryo below the cotyledons.

Rank. A vertical row; leaves that are 2-ranked are in 2 vertical rows, and may be alternate or opposite.

Raphe. The cord or ridges formed by the funicle along the side of some ovules.

Ray floret. Outer modified floret of some Compositae with a ligulate corolla; one of radiating branches of an umbel.

Receptacle. The torus of a flower.

Recurved. Bent or curved downward or backward.

Reflexed. Abruptly recurved.

Regular flower. Symmetrical; actinomorphic; flowers that can be vertically divided into two equal halves by any plane.

Reniform. Kidney-shaped.

Reticulate. Having the veins connected together like the meshes of a net.

Retinaculum. A persistant hook-like, upcurved and subsequently hardened process from the placenta in most Acanthaceae on which the ovules and seeds are borne.

Retuse. With a slight notch in a rounded or truncate apex.

Revolute. Having the margins or apex rolled backward upon the under surface.

Rhizome. A modified underground stem.

Ribbed. With alternate ridges and furrows.

Rosette. An arrangement of leaves radiating from a crown and usually at or close to the earth.

Rotate. Wheel-shaped; said of regular gamo-petalous corolla with a short tube and a flat spreading limb.

Rotund. Circular or nearly so in outline.

Rudimentary. Imperfectly developed and non-functional.

Rugose. Wrinkled.

Runner. A slender prostrate shoot rooting at nodes.

Saccate. Bulged into a small bag or cavity.

Sagittate. Shaped like an arrow-head.

Salveform. With a long tube and horizontally spreading limb; salver-shaped.

Samara. An indehiscent dry fruit with a wing developed from the pericarp.

Saprophyte. A plant that is nourished by dead organic matter.

Scabrous. Very rough to the touch owing to short stiff hairs.

Scape. A leafless and generally unbranched peduncle arising from the ground.

Scarious. Thin, dry, membranous, somewhat stiff and not green.

Schizocarp. A general name for dry fruit which on maturity splits into one-seeded portions.

Scorpioid Cyme. A determinate inflorescence with the lateral flowers or branches borne alternately on opposite sides of an apparent axis.

Sepal. One of the segments of the calyx, especially when not combined.

Sepaloid. Green and resembling a sepal in structure.

Sepatate. Partitioned.

Septicidal. A form of dehiscence of a ripe carpel when it opens through the dissepiments or lines of junction of the carpels.

Septum. A partition referring especially to that of a compound ovary.

Sericeous. Covered with silky straight hairs.

Serrate. Toothed like a saw with the teeth directed forward.

Serrulate. Minutely serrate.

Sessile. Without a stalk.

Seta. A bristle.

Setaceous. Bristle-like.

Silique or *Siliqua* or *Silicle.* A long, narrow, many-seeded fruit, developing from a superior, bicarpellary ovary with two parietal placentas. It dehisces from below upwards by both the sutures. The ovary is one-chambered, owing to the development of a false partitition wall, called replum, which extends from one placenta to the other. Siliqua is found in Cruciferae.

Simple. Undivided; consisting of one blade when said of a leaf; resulting from a single pistil when said of a fruit; unbranched when said of a stem, tendril or style.

Sinuate. With abruptly wavy margin.

Sinus. The space between the divisions or lobes of a leaf.

Spadix. A spike with a thickened or fleshy axis bearing unisexual flowers generally sheathed in a spathe, as in members of the Araceae.

Spathe. The leaf-like coloured bract investing the inflorescence.

Spatulate. Shaped like a spatula i.e., oblong with a broad and rounded apex and gradually narrowed base.

Species. A group of individuals alike in all essential particulars; the sub-divisions of a genus.

Spike. A racemose inflorescence bearing sessile flowers, on an undivided axis.

Spikelet. A secondary spike; an ultimate branchlet of the inflorescence of grasses and Cyperaceae generally consisting of one or more flowers subtended by glumes.

Spine. A strongly pointed woody process consisting of a modified branch, sometimes of a modified leaf.

Spinescent. Terminating in or resembling a spine-like sharp point; also becoming spinous.

Spinose, Spinous. Furnished with or of the nature of spines.

Spiral. Arranged in a winding series (leaves)

Spore. A minute unicellular body which detaches itself at maturity and is instrumental in the process of sexual reproduction in Cryptogams.

Spur. A tubular or saclike projection from the perianth, as in Balsam, Garden Nasturtium and Larkspur.

Stamen. The male organ of a flower, consisting of a filament and an anther.

Staminode. An abortive or anther-less stamen.

Standard. The posterior or odd petal of a papilionaceous corolla.

Stellate. Star-shaped; with radiating rays like points of a star.

Sterile. Not productive.

Stigma. That part of the pistil which is specially adapted for the reception of the pollen for the fertilization of the ovules.

Stipel. A secondary stipule, the appendage of a leaflet.

Stipule. A leaf-like appendage of the base of the petiole, usually one on either side of it.

Stolon. A prostrate or reclined shoot along the surface of the ground rooting at intervals and giving off shoots which become independent plants.

Stonefruit. The hard endocarp of a drupe. Syn. Putamen, especially as in Rosaceae.

Striate. Marked with thin longitudinal lines or minute furrows.

Strigose. Covered with sharp pointed straight stiff hairs of unequal length.

Style. The stalk-like part between the ovary and the stigma.

Stylopodium. A fleshy disk on the base of some styles.

Subulate. Shaped like a cobbler's awl: narrow, tapering and somewhat stiff.

Succulent or *Fleshy.* With abundant cellular tissue full of juices.

Sulcate. Grooved or furrowed with the depressions more or less parallel.

Superior. Inserted on the ovary or adnate to it, is said of the calyx; above the calyx a free from it, if said of the ovary; also posterior in position.

Suture. A seam indicating the line of union of two parts; a line of dehiscence of dry fruits.

Sympetalous. Petals united, atleast at the base; gamopetalous.

Synpodial inflorescence. A determinate inflorescence that simulates an indeterminate inflorescence due to suppression of lateral branches or flowers successively on the same side (Helicoid) or on alternate sides (Scorpioid).

Synandrium or *Synandrous.* With coherent anthers as in some aroids.

Syncarpous. Carpels united.

Syngenesious. Stamens united by their anthers, as in Compositae.

Tendril. A slender process usually belonging to the axis and serving as a support in climbing.

Tepal. A division of a perianth.

Terete. Cylindrical, rounded in cross section.

Ternate. Arranged in threes in a cluster of whorl.

Testa. The outer most coat of the seed.

Tetradynamous. With four long and two short stamens, as in most Cruciferae.

Tetramerous. Said of flower having the parts or members in each whorl in fours.

Tetrandrous. With four stamens.

Thalamus. That part of the axis of a flower which supports the floral whorls and the pistil. Syn. Torus.

Tiller. A sucker from the base of a stem.

Tomentose. Covered with short, soft, rather dense and more or less tangled hairs.

Torus. Receptacle.

Trimerous. Said of a flower having the parts or members in each whorl in threes.

Trichotomous. With the divisions always in threes and of more or less the same length.

Tricuspidate. With three cusps or sharp points.

Tristichous. In three vertical rows.

Truncate. Ending abruptly, as if with the end cut-off.

Tuber. A thickened underground stem bearing buds or eyes e.g., potato.

Tuberous. Swollen like a tuber.

Turbinate. Shaped like an inverted cone; top-shaped.

Twiner. Spirally coiling climber.

Umbel. A form of racemose inflorescence in which several branches or pedicels radiate form the top of a common peduncle and are of nearly the same length.

Umbelliform. Resembling like an umbel.

Undulate. With a wavy margin.

Unicostate. Applicable to venation with one prominent midrib. There may be reticulate unicostate or parallel unicostate. Also called *pinnate.*

Unilateral. Arranged on one side of the axis.

Unilocular. With a single chamber or cell, as in an ovary.

Unisexual. Of one sex; having the stamens and the pistil in separate flowers.

Urceolate. Urn-shaped.

Urticle. A one-celled one-seeded fruit with a thin and more or less loose pericarp.

Valvate. With the margins of the members of a whorl (segments of perianth) only meeting without overlapping; also opening by valves.

Venation. The mode in which the nerves or veins are disposed in a leaf.

Ventral. Front, relating to inner face. Opposite of dorsal.

Ventricose. With unequal swelling.

Vernation. The arrangement of leaves in the bud, while arrangement of perianth or its parts in the bud is known as *"aestivation"*.

Versatile. Moving freely, as an anther attached by the back to the attenuated top of the filament on which it swings.

Verticellate. Arranged in whorls.

Verticillate Inflorscence. A very much condensed cyme, formed of shortly stalked flowers resembling a cluster of sessile flowers forming a false whorl, is found in the axils of opposite bracts or leaves e.g., in Ocimum. (Labiatae).

Vexillum. The broad upper petal of papilionaceous corolla (*standard*).

Villous (*Villose*). More or less thickly covered with long soft simple hairs.

Vitta (*plu. Vittae*). One of the oil receptacles in an umbellifer fruit.

Wing. Any thin membranous appendage; the side petals of a papilionaceous corolla.

Xerophyte. Plants that grow naturally in dry places; they can withstand a prolonged period of drought uninjured; for this purpose they have certain adaptations.

Zygomorphic. Flowers (particularly corollas) which have a bilateral symmetry.

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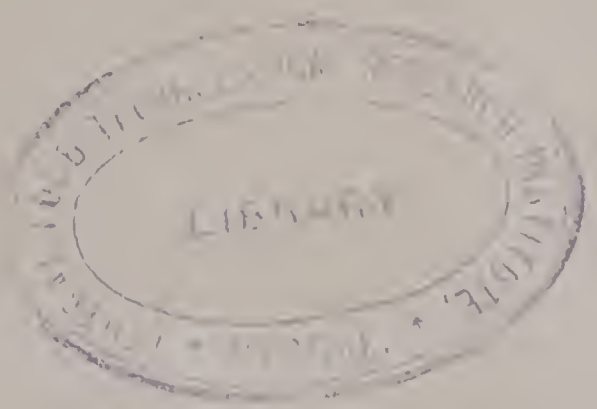

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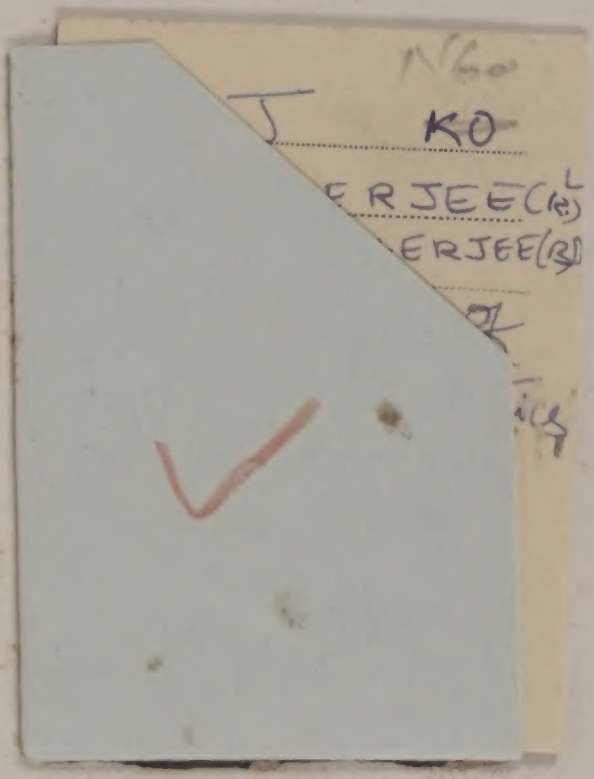
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